Technical Report 1700-TR

TAN VERSUS GREEN COLORATION FOR COMBAT UNIFORMS IN HOT-DRY AND HOT-WET TERRAINS

Project 8-31-02-004

15 November 1961

U. S. Army Engineer Research And Development Laboratories

FORT BELVOIR, VIRGINIA

U. S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
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Distributed by

The Director
U. S. Army Engineer Research and Development Laboratories
Corps of Engineers

Prepared by

John H. Hopkins
Camouflage Branch
Military Department
U. S. Army Engineer Research and Development Laboratories
Corps of Engineers
Fort Belvoir, Virginia

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PREFACE

Authority for conducting this study is contained basically in letter, ENGNB, Chief of Engineers, to Commanding Officer, Engineer Research and Development Laboratories, 3 June 1948, subject: "Patterns, Camouflage Clothing, Project 8-31-02-004, Approval of Military Characteristics and Authorization of the Project." (Project 8-31-02-004 was superseded by Project 8-31-02-104.) Copies of the authorizing letter and project card are included in Appendix A, Exhibit 1. Specific direction regarding this phase of the project is contained in the following:

a. Letter, ENGNF, Chief of Engineers, to Chief, Army Field Forces, 18 December 1950, subject: "Personal Camouflage Requirements," with 2 indorsements (Appendix A, Exhibit 2).

b. Letter, GNBOG 421, President, Army Field Forces Board No. 3, through Chief of Army Field Forces, to Department of the Army, 20 November 1952, subject: "Ensemble, Hot-Wet" (Appendix A, Exhibit 3).

c. Letter, ENGNF (G/8-31-02-004), Chief of Engineers, to Commanding Officer, ERDL, 3 June 1953, subject: "Camouflage Hot-Dry, Hot-Wet Uniforms," with 1 inclosure (Appendix A, Exhibit 4).

d. Letter, ENGNF (E-8-31-02-004), Chief of Engineers, to Commanding Officer, ERDL, 1 July 1953, subject: "Uniforms, Hot-Wet and Hot-Dry Climates" (Appendix A, Exhibit 5).

e. 1st Ind, ENGNF (G/02-004), Chief of Engineers, to Commanding Officer, ERDL, to letter, TECHD MG 8-31-02-004, ERDL, to Chief of Engineers, 15 October 1953, subject: "Equipment, Supplies, and Services for Panama Camouflage Tests" (Appendix A, Exhibit 6).

The study was conducted in two parts, with the field work accomplished by two test teams under the active direction of John H. Hopkins. The teams were composed of the following additional personnel

Hot-Dry Phase

Joseph F. Hannigan, Special Camouflage Projects Section, Camouflage Branch, ERDL, Physicist, assistant test engineer.

John Pusey, Lt., CE, The Engineer School, observer.

Albert Gaudreault, Technical Photographic Branch, ERDL, photographer.

Frederick M. Kirby, Transportation Branch, ERDL, driver.

Six enlisted men from ERDL and Yuma Test Station, drivers and models.

Sir Hubert Wilkins, Office, Quartermaster General, liaison and advisor.

Hot-Wet Phase

Edward J. Bierly, Concealment Section, Camouflage Branch, ERDL, Camouflage Specialist, assistant test engineer.

Sidney L. Feldman, Technical Photographic Branch, ERDL, photographer.

Eight enlisted men from local commands, drivers and models.

Sir Hubert Wilkins, Office, Quartermaster General, liaison and advisor.

The following persons visited the test team to observe portions of the study during its progress:

R. T. Mathews, Maj, AFF Board No. 3 (Desert and Panama).

H. S. Tye, Maj, AFF Board No. 3 (Desert).

T. L. Bailey, OQMG (Desert).

Robert Woodbury, OQMG (Panama).

During the course of the study, liaison was maintained between the ERDL test team and the Quartermaster Field Test Teams at Yuma, Arizona, and at Fort Sherman, Canal Zone. During the hot-dry phase, daily contact with Dr. Goddard and Capt Reed of the Quartermaster Test Team was maintained through the Engineer Test Team Headquarters at Yuma Test Station. While at Fort Sherman, the test team maintained liaison on a daily basis directly with Capt Reed.

In addition to the above personnel directly engaged in this study, general support was obtained from Yuma Test Station and Headquarters, USARCARIB, and, in particular, from the Engineer Test Team under Mr. Uhl and the Jungle Warfare Training Center under Lt Col Stutler.

CONTENTS

SUMMARY

This report covers that portion of a 1953 investigation of patterns, coloration, near infrared reflectance, and fluorescence to determine the military advantages of any specific camouflage coloration for hot-dry and hot-wet terrains when applied to combat uniform ensembles in particular. The report is being published at this time as a matter of historical and general interest and as a result of recent renewed interest by the Army in the area of protective concealment of individuals. The data and findings contained herein together with previous and allied work in this and other types of world terrains and environments formed the basis for recommendations made in 1953 to higher headquarters. These recommendations have been implemented wherever possible. The work resulted from a recommendation by Army Field Forces Board No. 3 that a single hot weather combat uniform was adequate to meet the needs of the Field Army. In 1951, a series of studies conducted locally and in the Southwestern United States had established colorations which were recommended for the hot-wet and hot-dry uniform ensembles. These 1951 studies and their results were based upon assumptions challenged by this Army Field Forces Board No. 3 action. Further, information regarding the need for special colorations for load carrying equipment was required to complete the camouflage recommendations with regard to combat uniforms.

The study consisted of a series of live model observations conducted in sites located in the Southwestern United States and in the Panama Canal Zone. These observations compared the thresholds of detection and the relative conspicuousness of the whole and various individual portions of combat uniform ensembles in four primary colors--Khaki No. 1, Tan 112, Green 116, Olive Green 107. An additional series of experimental patterned and colored uniforms were observed in Panama.

The report concludes that:

a. There is a significant military advantage gained from the use of tan coloration in hot-dry terrains (deserts) and from the use of green coloration in hot-wet (tropical) areas.

b. Light tan coloration (as exemplified by the Khaki No. 1 and Tan 112 colors used in these tests) provides significantly superior camouflage over green and olive-drab colors for combat uniforms to be used in desert (hot-dry) and semidesert terrains.

c. Medium dark yellow-green coloration (as exemplified by the experimental summer temperate color QM Code RPS-1, Olive Green 107, and Green 116) provides significantly superior camouflage over the

tan and khaki colors for combat uniforms to be used in tropical (hot-wet) terrains.

d. The experimental nylon flock-patterned uniform was superior in camouflage effectiveness to all others with which it was compared in the Panama Canal Zone.

e. The superior camouflage effectiveness of the Green, QM Code RPS-1, over the solid shade colors with which it was compared was sufficient to warrant its adoption as coloration for hot-wet combat uniform ensembles.

f. If worn outside the jacket, body armor requires special colorations matching those recommended for the uniform for significant camouflage effectiveness to be retained.

g. Light tan load carrying equipment and small auxiliary equipment carried by the individual, while not conspicuous except at close range (under 600 yards), provide additional camouflage worthy of consideration for use with hot-dry uniform ensembles.

h. There is insufficient additional camouflage gained to warrant special coloration other than Olive Green 107 for load carrying equipment and other small auxiliary equipment carried by average troops in tropical (hot-wet) terrain.

i. The burlap helmet cover in colors to match the respective uniform with which worn is significantly superior to other types with which it was compared.

j. The Tan 112 coloration is superior to Khaki No. 1 in hot-dry terrain at ranges over 300 yards; the opposite is true under 300 yards, but the advantage is slight in either case.

k. Although the spray can colorant is capable of performing its camouflage mission adequately, it is unsuitable for field use in its current form.

l. The use of face paint should be vigorously taught in all units being trained for duty in heavily foliaged terrain.

TAN VERSUS GREEN COLORATION FOR COMBAT UNIFORMS

IN HOT-DRY AND HOT-WET TERRAINS

I. INTRODUCTION

1. Subject. This report covers that portion of the investigation under Project 8-31-02-004, "Patterns, Camouflage Clothing," which was conducted during 1953 in the Southwestern United States and the Panama Canal Zone. This study was conducted for three purposes:

a. To determine the degree of military advantage gained from the use of specific coloration for combat clothing in hot-dry and hot-wet terrains.

b. In the event that a specific color is found significantly superior, to determine the degree of advantage gained from the use of this color in lieu of standard Olive Green or other colors for auxiliary personnel equipment.

c. To evaluate the colorations previously recommended for hot-wet and hot-dry areas.

2. Background and Previous Investigation. This report covers one phase of a project begun as an investigation of colored patterns and infrared reflectances to determine the camouflage potential of these elements for application to the combat uniform. Conferences between personnel of the Corps of Engineers, Quartermaster General, and Army Field Forces revealed a pressing requirement for a determination of colors and reflectances for a series of new combat uniform ensembles and auxiliary personnel equipment being developed by the Quartermaster Corps. These conferences also led to searching evaluations of the most fundamental aspects of troop camouflage and eventually to a set of general principles supported by OCAFF.[1] Fundamental to these principles are two assumptions: first, that even imperfect concealment provides a military advantage and second, that a coloration match to the terrain is an aid to concealment. These assumptions and principles remained unchallenged throughout the subsequent studies conducted locally with regard to coloration for live foliage terrains and, in the Southwestern United States, with regard to coloration for the hot-dry terrains. The hot-dry studies were conducted in 1951 by a field test team and were designed to obtain data upon which to base an optimum coloration choice for combat

1. Letter, ENGMF, Chief of Engineers, to Chief, Army Field Forces, 18 Dec 1950, subject: "Personal Camouflage Requirements" (paragraph 6), with 1st Indorsement (Appendix A, Exhibit 2).

uniform ensembles being developed by the Quartermaster Corps. While these studies were extensive and detailed, they did not attempt to prove or disprove the fundamental assumptions which it was thought had been firmly established by time and experience. However, AFF Board No. 3 challenged these assumptions in November 1952 by recommending that a requirement be established for a single hot weather uniform in lieu of the two uniforms (hot-dry and hot-wet) then under development.[2] As a result of statements by OQMG and OCE objecting to this recommendation, a meeting was held at the Pentagon on 14 May 1953 under the auspices of Col W. S. Triplet, Chief, Development Branch, R&D Division, ACofS G-4. At this time, the views of personnel of AFF Board No. 3, OQMG, and OCE were presented and an agreement was reached to pursue both the Quartermaster and Corps of Engineers studies to their conclusion. As far as the Corps of Engineers was concerned, special consideration was to be on the necessity for coloring load carrying equipment to match the color of the uniforms. Subsequent directives as shown in Appendix A were received from OCE as indicated, and the procurement of equipment and personnel and coordination with Quartermaster and Army Field Forces agencies was begun.

II. INVESTIGATION

3. Approach. The general approach consisted of traveling to the terrain type in question and, by a series of observations under different lighting conditions of live models wearing uniforms and equipment ensembles, comparing the camouflage effectiveness provided by the colorations in question. To make the results as valid as possible, a variety of terrains chosen from data gathered in 1951 as being representative of important terrain types throughout the world (Fig. 1) were used as test sites. Further, the observations were recorded individually, and both still and motion pictures were made for evaluation through that detection medium and for illustrative purposes. The types of observations and the emphasis were necessarily altered to meet the peculiar character of desert versus tropical areas.

Advantage was taken of the opportunity to extend the desert test program undertaken during 1951. Threshold visibility and identification studies were carried on in the desert, and the spray can field colorant was tested as a field patterning method in the tropics. Also, in Panama, experimental patterns developed earlier were tested and compared in effectiveness to solid shades. Finally,

2. Letter, GNBCG 421, President, Army Field Forces Board No. 3, through Chief of Army Field Forces, to Department of the Army, 26 November 1952, subject: "Ensemble, Hot-Wet" (Appendix A, Exhibit 3).

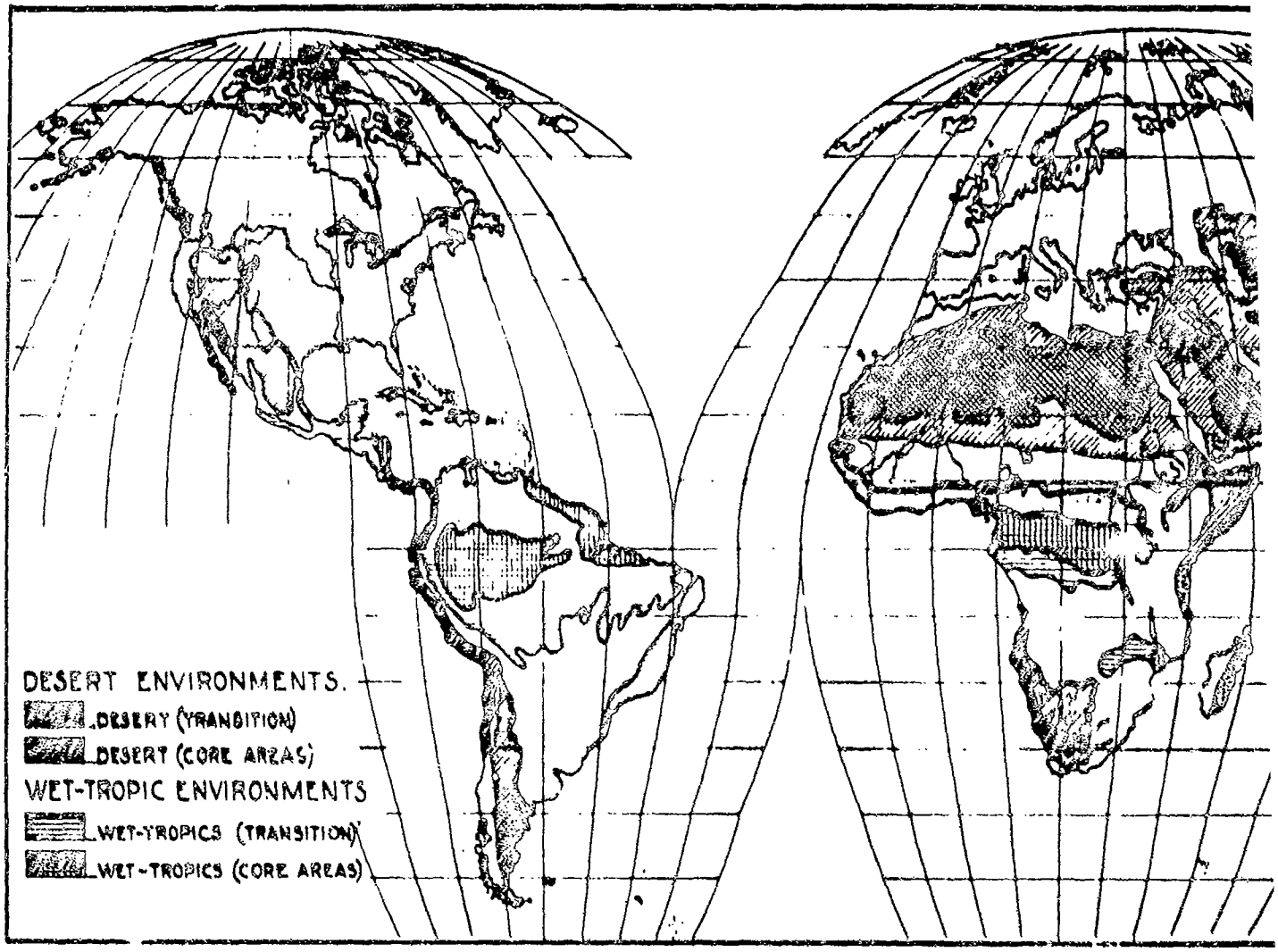
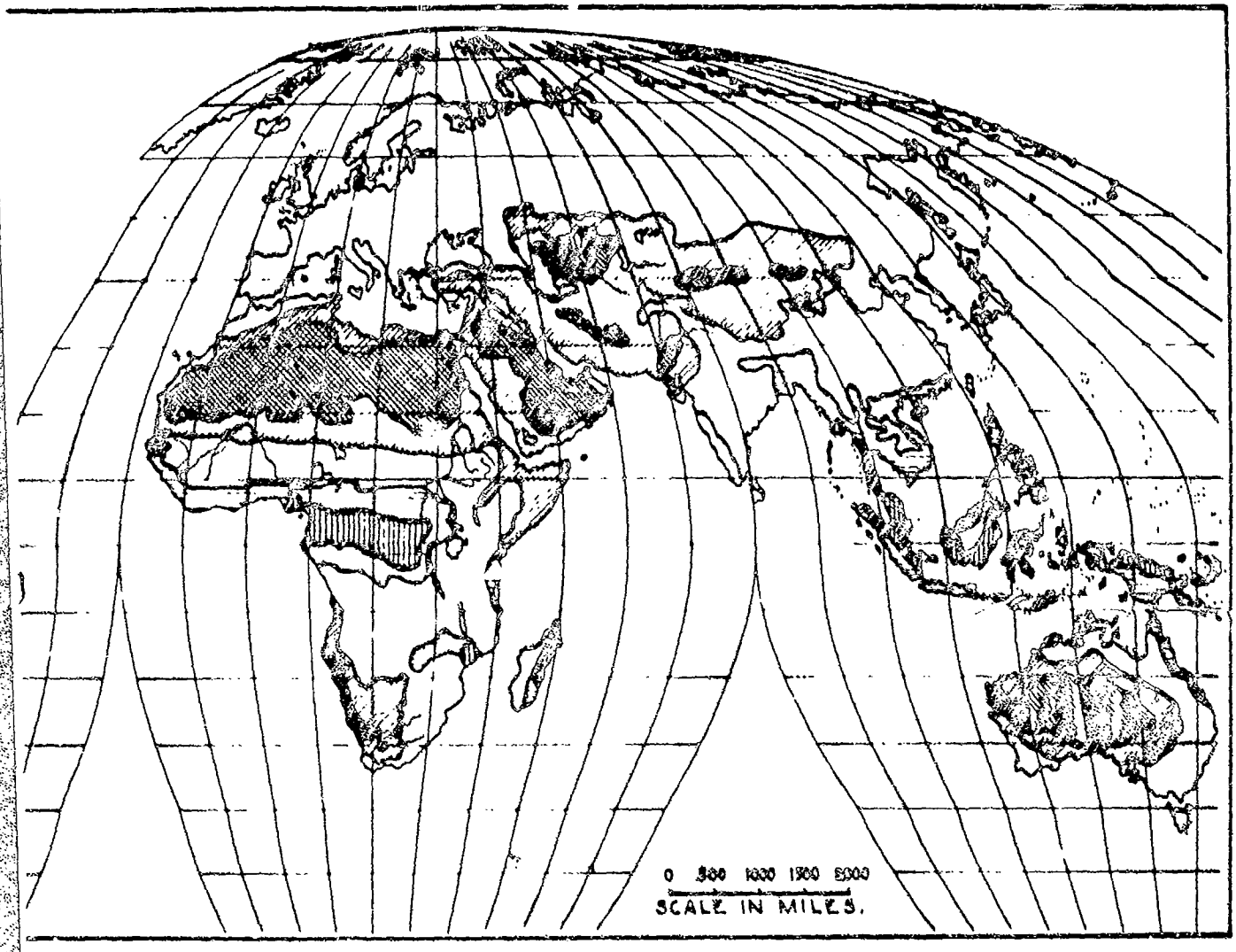


Fig. 1. World areas representative of types of terrain studied



as representative of types of terrain studied in this report.

the infrared recommendations previously made were checked with infrared film and with a sniperscope.

To make the findings of these studies available at the earliest possible date, summary reports were written immediately following each phase and forwarded to the Chief of Engineers for action. These reports are contained in the following:

a. Letter, TECRD MC 8-31-02-004, ERDL, to Chief of Engineers, 19 Nov 1953, subject: "Report, Conclusions, and Recommendations Tan Versus Green Coloration for Hot-Dry Combat Uniforms."

b. Letter, TECRD MC 8-31-02-004, ERDL, to Chief of Engineers, 28 Jan 1954, subject: "Report, Conclusions, and Recommendations of Green Versus Tan Coloration for Hot-Wet Combat Uniforms."

4. Equipment. Since the end item of this study consists of specifications of color, reflectance, and pattern, all equipment used is considered to be supporting-type equipment. For clarity, however, the equipment used is listed in three categories:

a. Transport. The transport used in the desert consisted of one station wagon from ERDL and one 1/4-ton truck and two 3/4-ton trucks from Yuma Test Station. In Panama, one 1/4-ton truck and one 3/4-ton truck obtained through local command were used.

b. General Support Equipment. General support equipment consisted of personnel gear, sniperscopes, photographic equipment, and supplies.

c. Test Items. Test items to be observed consisted of combat uniforms in four colors supplied by the Quartermaster Corps, together with load carrying equipment, body armor, and helmet covers in similar colors as shown in Table I.

Table I. Test Items Observed

Item	Green 116		Tan 112		Olive Green 107		Khaki No. 1	
	D	J	D	J	D	J	D	J
Uniform	4	4	4	1	4	1	4	1
*Load carrying equipment	1	2	2	2	4	1	1	1
Burlap helmet cover	4	4	4	1	4	1	4	1
Body armor	0	0	2	0	2	2	0	0

Key: D = desert J = jungle

* Included suspenders, combat pack, canteen and cover, cartridge belt, bandoleer, entrenching tool and cover, and first aid packet and case. (Items used in desert field colored. Items used in Panama precolored by Quartermaster.)

In addition to the items listed above, in Panama eight experimental patterned uniforms, one experimental foliage green uniform coded RPS-1, five controlled infrared reflectant uniforms, four cloth patterned helmet covers including Marine Corps standard, two Olive Green 107 sleeping bags, two two-man tents, and a series of colored cloth samples were used in the tests and observations.

A complete listing of items of equipment used in both the desert and Panama is contained in Appendix B.

5. Itinerary. The studies were conducted in the field; therefore, the following itinerary of activities with reference to Figs. 2 through 14 will provide some idea of the scope of the activity:

a. 14 May 1953 - ACofS G-4 conference with AFF, OQMG, and OCE.

b. 3 June 1953 - OCE directive to conduct the tests.

c. 3 to 27 June 1953 - Preparation (test plan, personnel, equipment, etc.) at ERDL.

d. 28 June to 1 July 1953 - Travel to Yuma Test Station, Yuma, Arizona.

e. 1 to 9 July 1953 - Preparation of equipment, obtaining transportation, checking test procedures, training of team.

f. 9 to 11 July 1953 - Travel to Belin, New Mexico.

g. 11 to 14 July 1953 - Air and ground reconnaissance of area to locate site.

h. 14 to 19 July 1953 - Testing at Rio Puerco Site north of Highway 66 10 miles west of Albuquerque, New Mexico.

i. 19 to 21 July 1953 - Travel from Albuquerque to Marble Canyon area. Flight to Yuma Test Station to report progress, clear enlisted men's pay, and converse with QM Test Team.

j. 21 to 24 July 1953 - Air and ground reconnaissance of Marble Canyon area and Monument Valley.

k. 24 to 28 July 1953 - Testing at Marble Canyon Site, 5 miles south of Navajo Bridge across the Colorado River, on west side of Highway 89, in Northern Arizona. Ground reconnaissance of Nevada and California.

l. 29 to 30 July 1953 - Team travel to Yuma Test Station.

m. 30 July to 3 August 1953 - Liaison with Quartermaster.

n. 3 to 5 August 1953 - Travel to Lancaster, California.

o. 5 to 10 August 1953 - Testing at Rosamond Site on Rosamond Dry Lake, 4 miles southeast of Rosamond, California.

p. 10 to 11 August 1953 - Travel to Westmorland, California.

q. 11 to 13 August 1953 - Testing at Westmorland Site, 12 miles north of Westmorland, California, ½ mile west of Highway 99.

r. 13 August 1953 - Travel to Yuma Test Station.

s. 14 August 1953 - Turn-in of equipment and release of personnel. Preparation of Yuma Test Station report.

t. 14 to 15 August 1953 - Travel to Fort Belvoir, Virginia.

u. 15 August to 30 October 1953 - Analysis of data.

v. 19 November 1953 - Submission of summary letter report to OCE.

w. 1 September to 15 October 1953 - Obtaining background data on tropics, Panama in particular.

x. 15 October 1953 - ERDL request to OCE for supplies and services for Panama tests.

y. 5 November 1953 - Directive from OCE to conduct tests in Panama.

z. 5 to 25 November 1953 - Preparations, shipping of material, etc.

aa. 25 to 29 November 1953 - Travel to Albrook AFB, Panama Canal Zone.

bb. 29 November to 4 December 1953 - Preliminary administrative preparations and obtaining of men and equipment.

cc. 4 to 17 December 1953 - Testing in Canal Zone at Fort Sherman and western side ranges.

dd. 17 to 19 December 1953 - Preparations for return.

ee. 19 to 21 December 1953 - Return to Fort Belvoir, Virginia.

ff. 21 December to 28 January 1954 - Analysis of data and preparation of summary report.

gg. 28 January 1954 - Submission of summary letter report to OCE.

6. Choice of Test Sites. The previous desert work in 1951 had been based upon rather extensive reconnaissance of the entire Southwest. The vagaries of arid and semiarid terrains, however, caused some delay when an attempt was made to reuse the sites previously selected in 1951. Fortunately, this possibility had been foreseen and contractual arrangements had been made which provided for the contracting of local flying services to perform aerial reconnaissance. These contracts also provided for aerial photography of tests and areas and, in one case, rapid personnel liaison with the Yuma Test Station from Albuquerque, New Mexico. Figure 2 shows the various aerial and ground reconnaissance made to find test sites suitable to the purpose. Such sites required grazing visual ranges up to 3,000 yards and of varying foliage cover and color to encompass terrain types found throughout the world.

The same fundamental needs underlay the choice of sites in Panama, but there the possibilities were confined to the Canal Zone and local knowledge was available to quickly locate the various tropical terrain types believed important to this study.

7. Description of Test Sites. Descriptions of the areas over which the various observations were made are given to illustrate the relationship of the various areas to the tests (observations) described later and to permit the results to be related to foreign areas of similar nature.

a. Hot-Dry Sites. The desert test sites selected were as follows:

(1) Yuma Site. The Yuma Site (Figs. 3 and 4) was situated just west of Arizona Highway 95 between the Laguna Mountains, the Yuma Test Station Access Road, and the Engineer Test Team Headquarters and was approximately 3 miles by road from that Headquarters. The terrain was generally flat and sloped gradually upward to the foot of the Laguna Mountains in the background. The observation area was located on a small rise that gave excellent visibility to the mountains. The maximum usable range was 2,800 yards. The surface consisted of

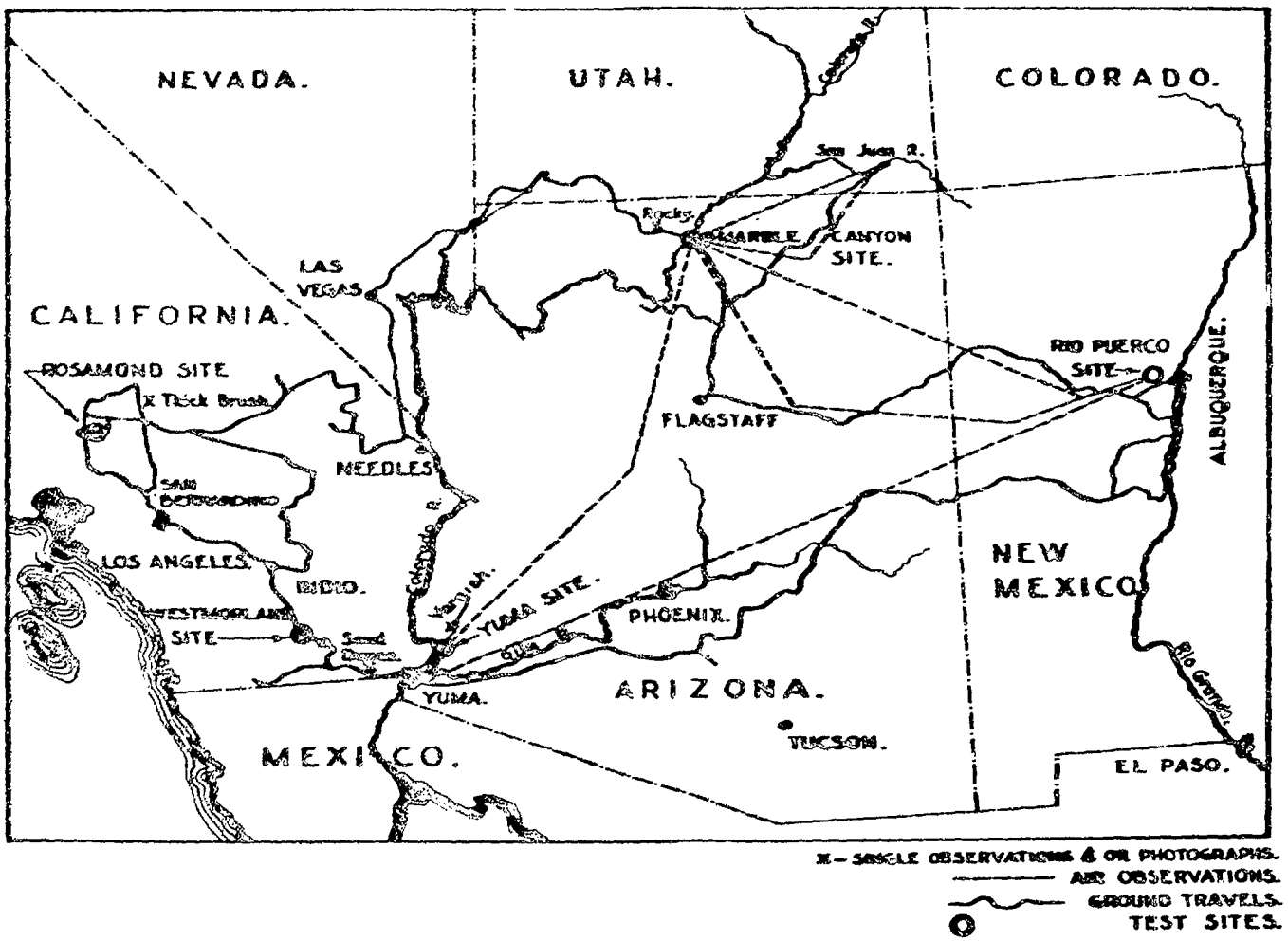


Fig. 2. Desert test sites, 1953.

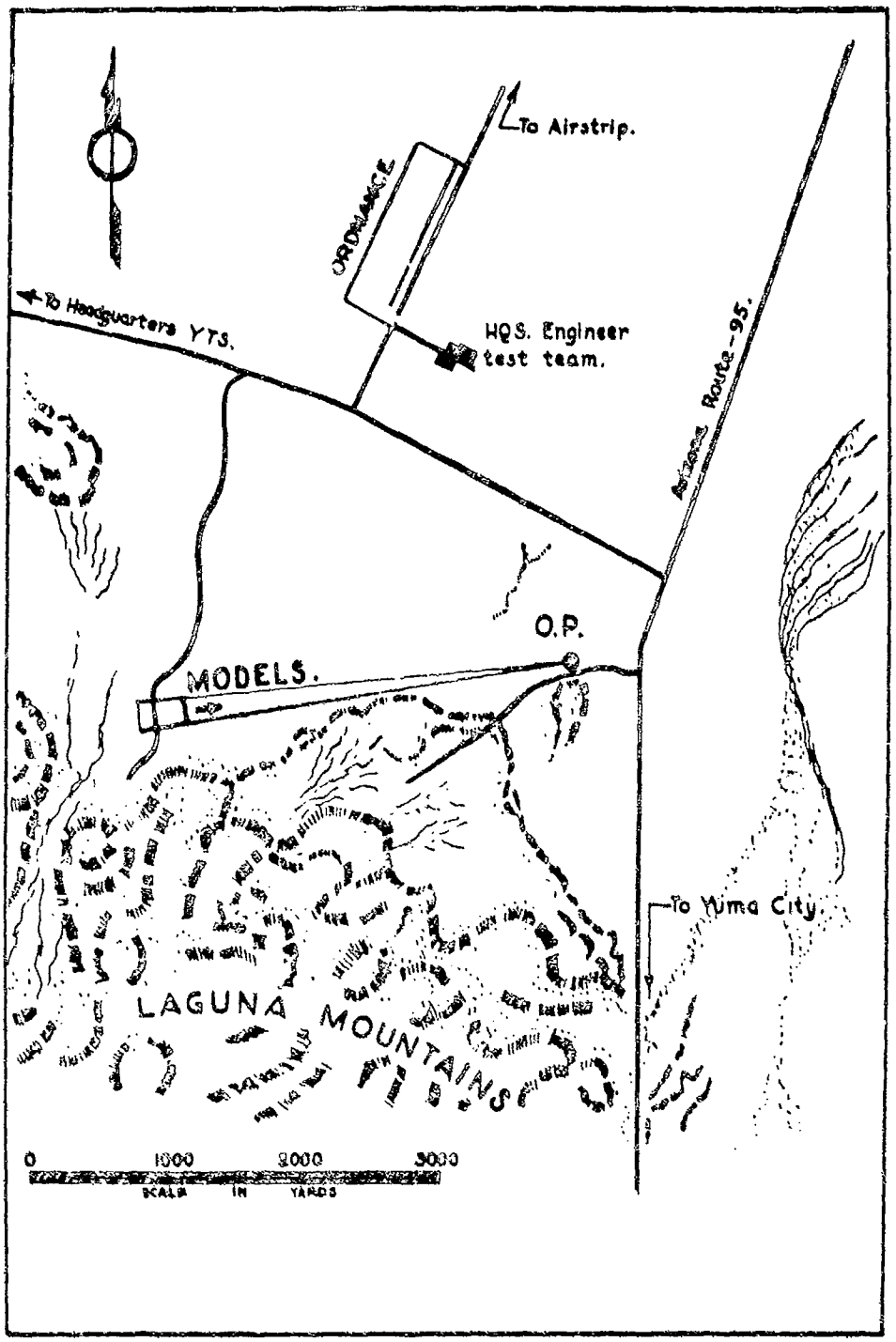


Fig. 3. Yuma Test Site.

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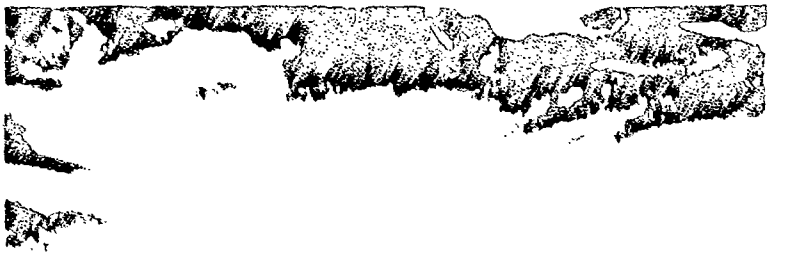

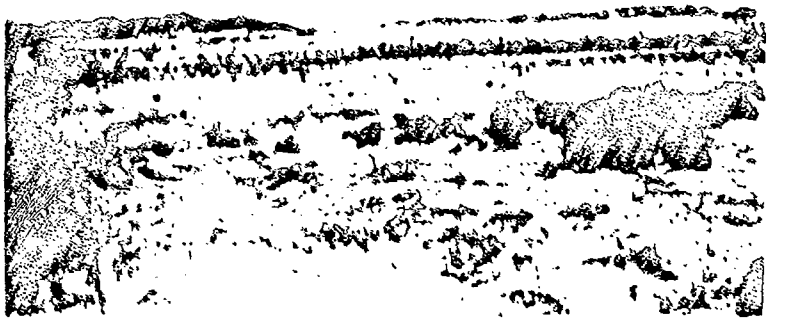

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Fig. . Ye[illegible] Test Air[illegible] South. Engineer D[illegible] Highway 89 to Wash at Big[illegible] Bottom. Ground view, looking out over [illegible]

sand and gravel with a trace of varnish on the pebbles of undisturbed areas. Foliage cover was slight and was concentrated along the washes. It consisted mostly of creosote brush averaging knee high. The general color of the area was light tan.

(2) Rio Puerco Site. The Rio Puerco Site (Figs. 5 and 6) was located 10 miles west of Albuquerque, New Mexico, just north of Highway 66. The site was on property belonging to the Armijo family and is a remaining portion of an original land grant. Permission for the use of the property was obtained from the Armijo family prior to the tests, and the property was given a routine inspection by a representative of the Albuquerque District Engineer's Office. The terrain was in the nature of a shallow bowl with the observation point located on a rise at the foot of a small bluff just off the highway, but shielded from view of traffic. The soil around the observation point and other high ground was loose sandy material, while the bottom land which the models traversed was dry and sun-cracked-aluvium deposited undoubtedly by flash floods of the Rio Puerco River which flowed just west of the site. The fine, light khaki colored soil was believed typical of playa surfaces in general and was selected for that reason. The vegetation was scant and low and consisted of widely scattered mesquite, burr sage, and some grass. Maximum range exceeded 3,000 yards.

(3) Marble Canyon Site. The Marble Canyon Site (Figs. 7 and 8) was located approximately 5 miles south of Navajo Bridge on Highway 89 in Northern Arizona. The observation point was located 1/8 mile west of the highway near an abandoned Indian hogan on the high end of a low fan lying between two arroyos emptying into Marble Canyon. The soil was primarily an orange-red sand. Due to recent rains, the area had considerable foliage cover consisting of the usual scattered creosote brush, northern sage, yucca plant, and some grasses. The area had a definite greenish tinge at long ranges, but, within the color threshold of observed uniforms, the reddish sand color predominated. This site was the most extensively foliated of all in which a full test series was carried out.

(4) Rosamond Site. The Rosamond Site (Figs. 9 and 10) was located on Rosamond Dry Lake approximately 15 miles by road from Lancaster, California, and 4 miles east of Rosamond, California. The lake is approximately 4 miles wide north to south and 5 miles long east to west and forms an almost perfectly flat surface completely devoid of vegetation. The general coloration of the surface varies from a light khaki to a deep orange-tan. The apparent coloration continually varies, depending upon the relationship of the viewer and light source. This phenomenon is exaggerated by the textured surface which results

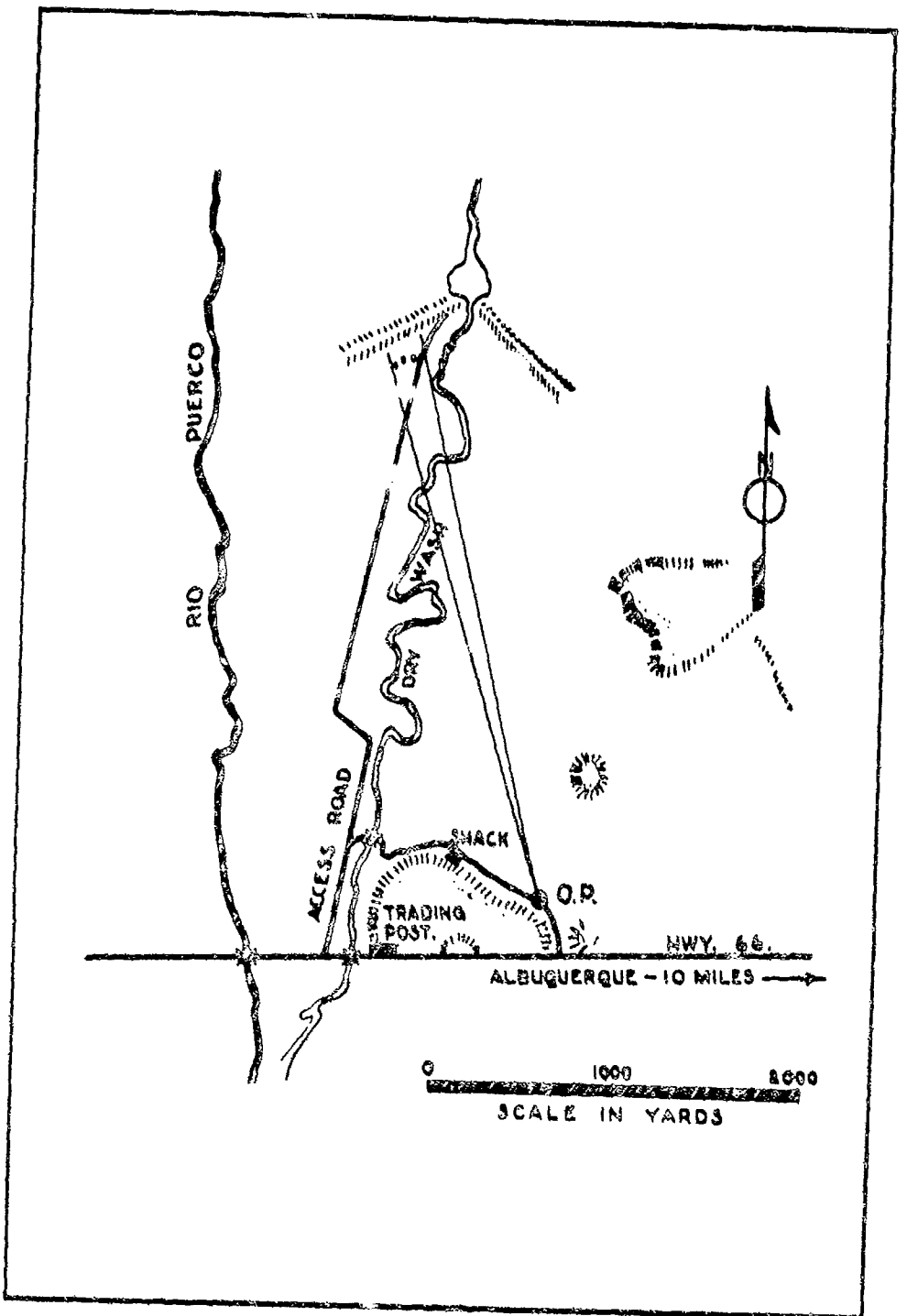

Fig. 5. Rio Puerco Test Site.

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Fig. [illegible]. Top: Air view. (Rio Puerco River [illegible] in upper center of photo.) Bottom: Ground [illegible] of same observation course from observation [illegible].

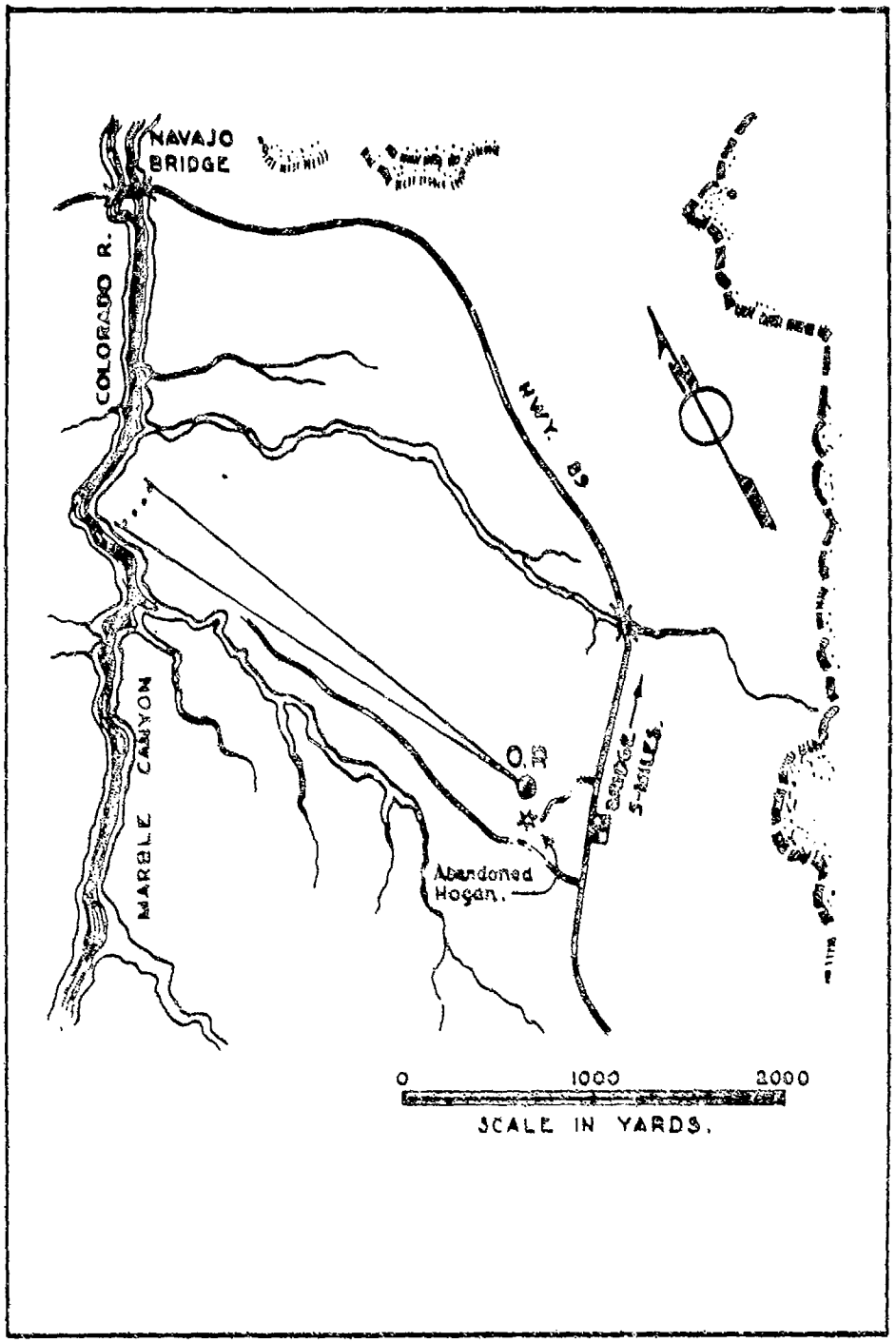

Fig. 7. Marble Canyon Test Site.

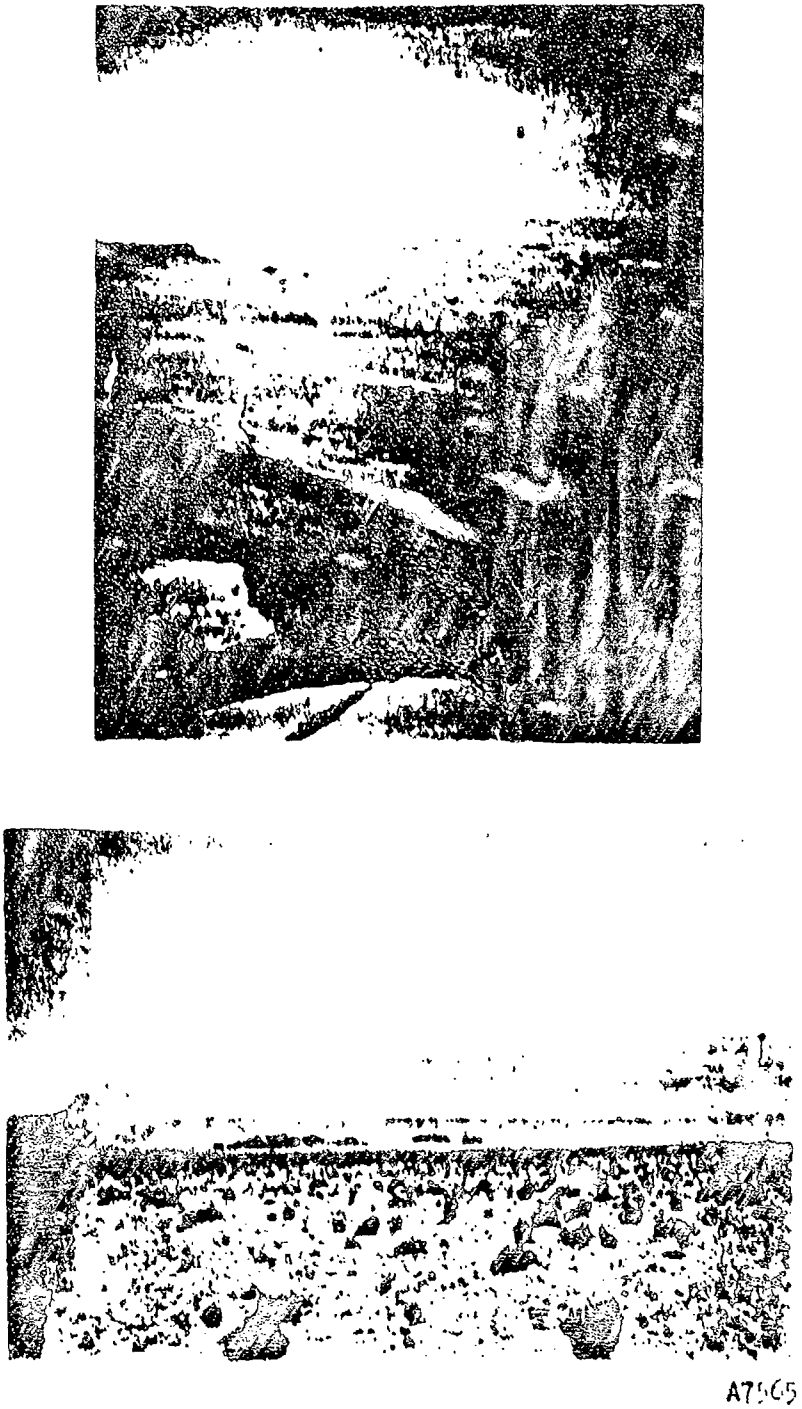

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Fig. . Middle Dragoon Test Site. Top: Air view, looking south from point northeast of Navajo Bridge. Bottom: Ground view, looking over terrain from near observation point.

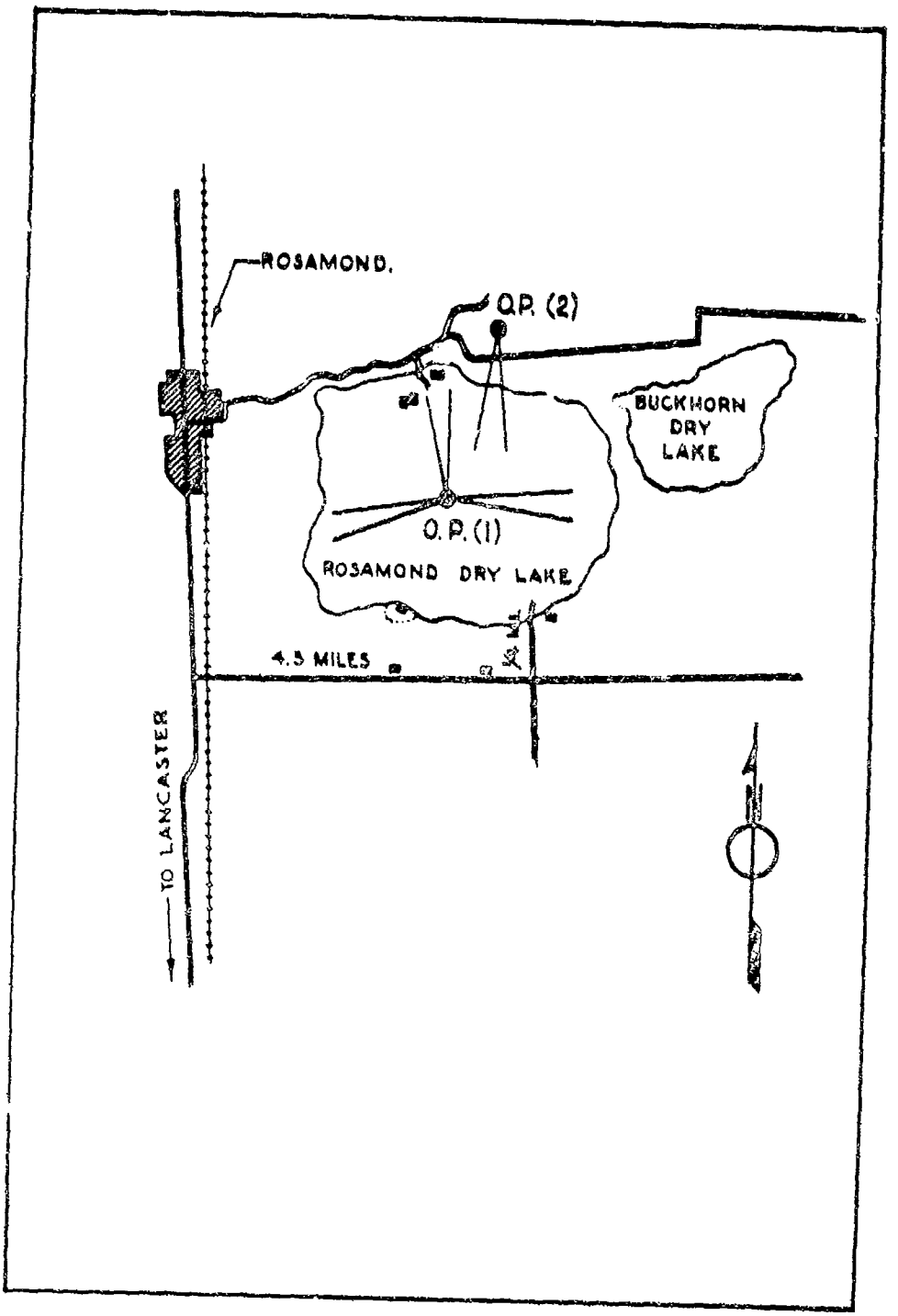


Fig. 9. Rosamond Test Site.

from the clumping of the dry clay. The soil is an alkali clay and has a hard surface which will support heavy vehicles. This site was chosen to obtain maximum uninterrupted visibility coupled with typical coloration which would permit the nearest outdoor condition approximating laboratory conditions.

(5) Westmorland Site. The Westmorland Site (Figs. 11 and 12) was situated about 12 miles north of Westmorland, California, ½ mile west of Highway 99, and opposite an installation known as Kane Spring. The area was cut by deep gullies unnoticeable from the observation point; this caused the models to disappear and reappear occasionally. The surface was a mixture of sand, gravel, and clay hardpan. The color was generally light tan with the lighter sketches more khaki colored. The vegetation was sparse and low and consisted almost wholly of creosote brush and sagebrush. The general appearance was believed typical of large areas of Africa and the Near East. The maximum usable range was limited to 850 yards in the western direction and 1,500 yards in the northern direction because of the land contour.

(6) Other Desert Sites. Additional single observations and photographs were made in areas of unique interest, either en route between the above described sites or in the general vicinity of the sites. These unique areas included sand dunes, thick brush, pavement, and rocky surroundings. The more important points are recorded in Fig. 2.

b. Hot-Wet Sites. With the exception of one circumstance, the observations made in the Canal Zone (Figs. 13 through 18) did not approach the ranges experienced in the desert. Further, the correlation of hot-wet terrain types had not progressed far at the time of these tests. Therefore, the selection of test sites was based on covering the generalized types of terrains to be encountered in hot-wet areas. The terrain types, grouped into the following general headings, were selected after discussions with officers and enlisted men of the Jungle Warfare Training Center:

(1) Short grass (representing savanna).

(2) Tall grass (representing savanna).

(3) Tropical cultivation.

(4) Mangrove swamp.

(5) Second growth jungle.

(6) Virgin (big tree) forest.

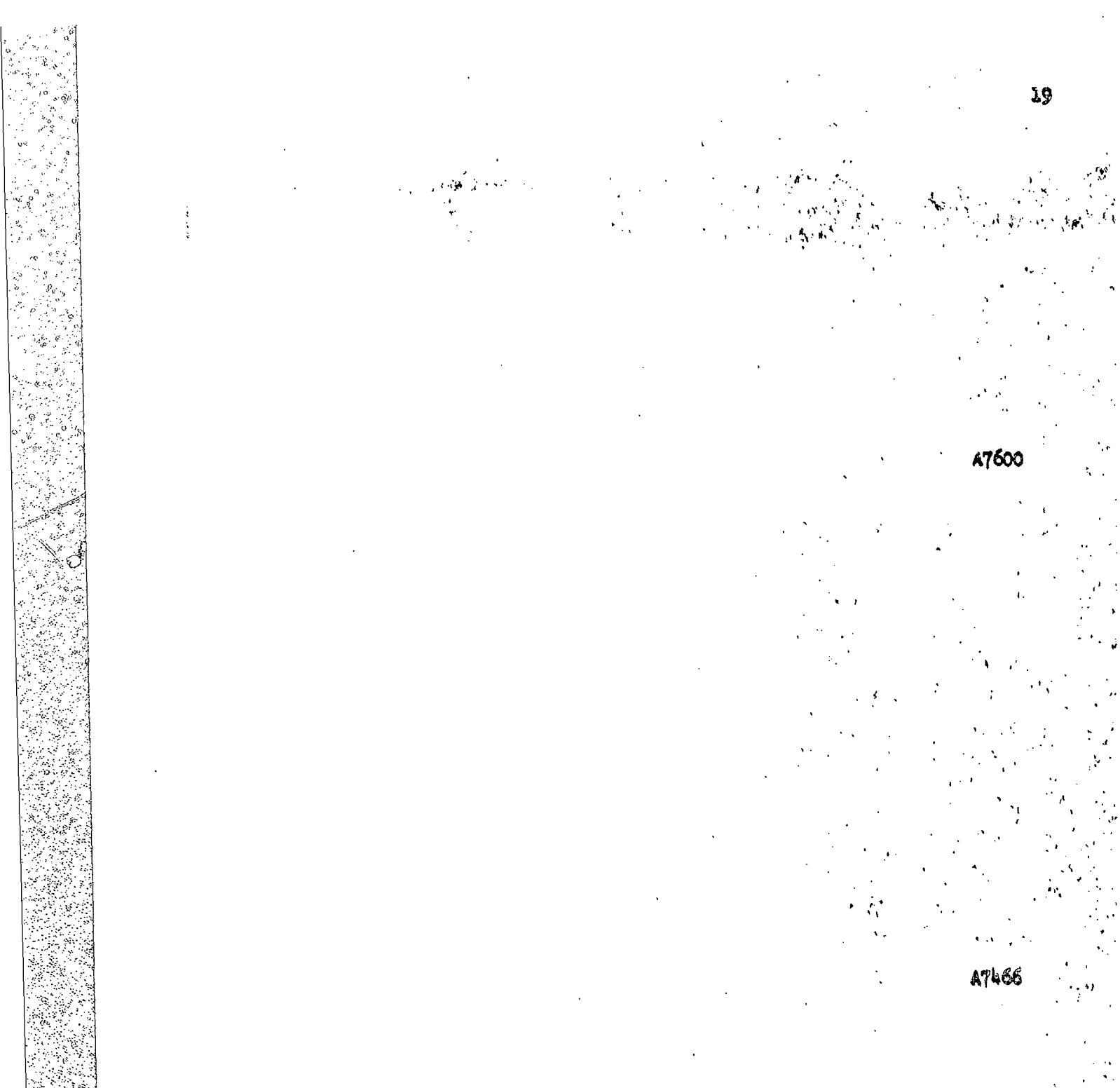
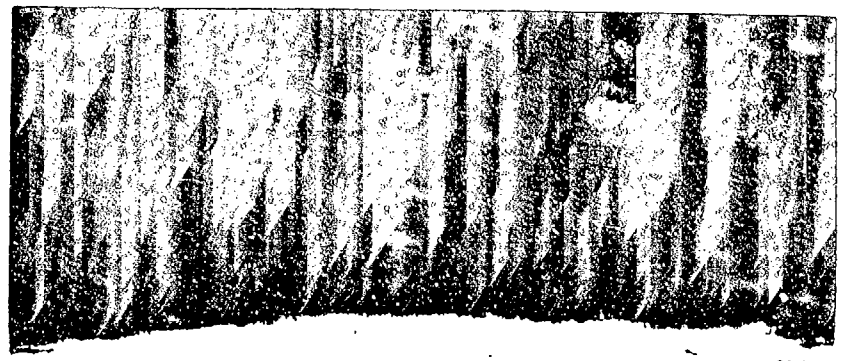
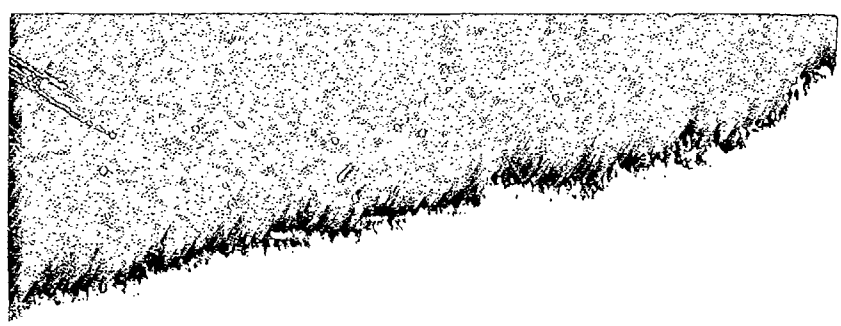
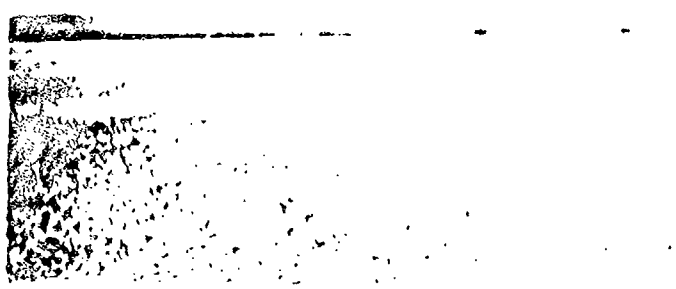


Fig. 10. Rosamond Test Site. Top: Infrared photograph, looking north. Bottom: Panchromatic photograph of same area as above. Close scrutiny will show mirage effect on far side of lake.







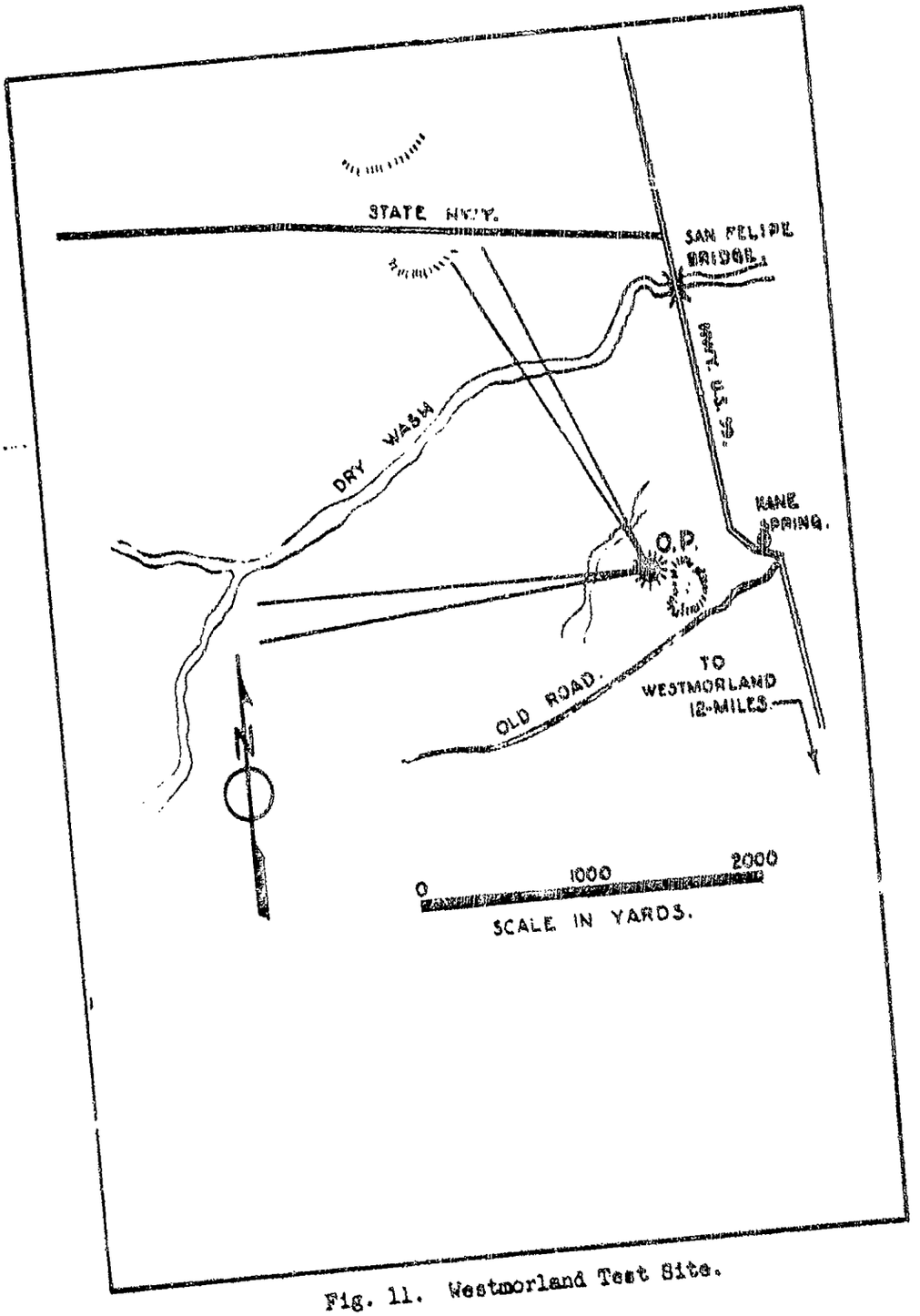


Fig. 11. Westmorland Test Site.

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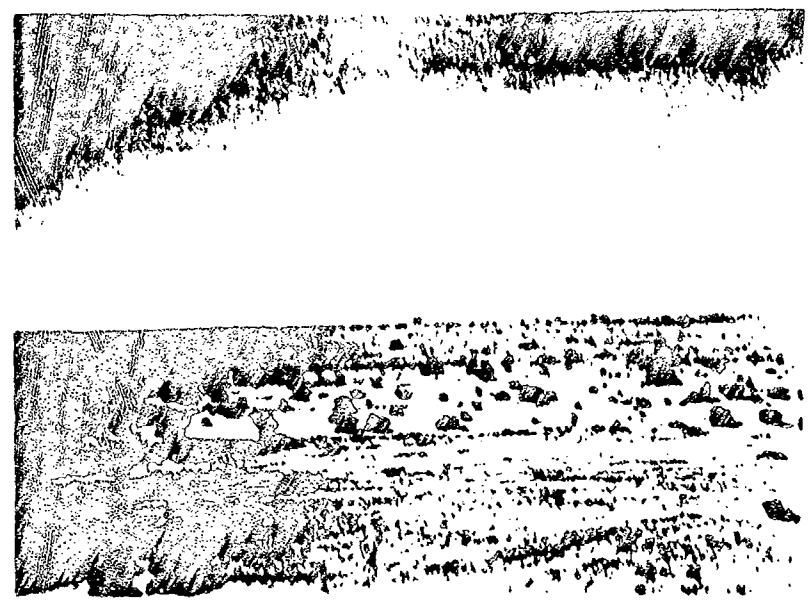

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Fig. 12. Westmorland Test Site. Top: Air view of general terrain in vicinity of Site. Bottom: Ground view, looking northwest from observation point.

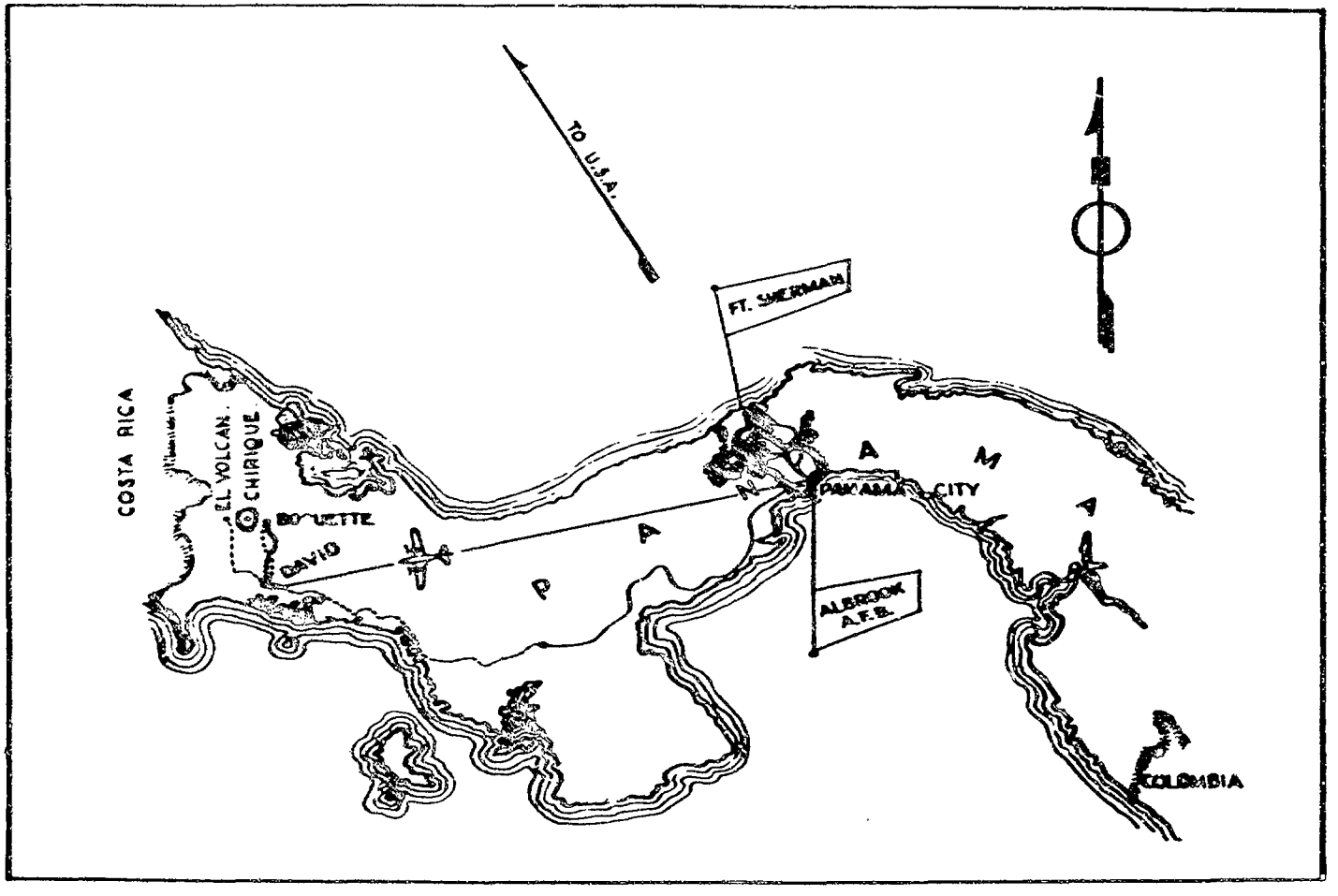


Fig. 13. General area of tropical studies, with route to Boquette indicated.

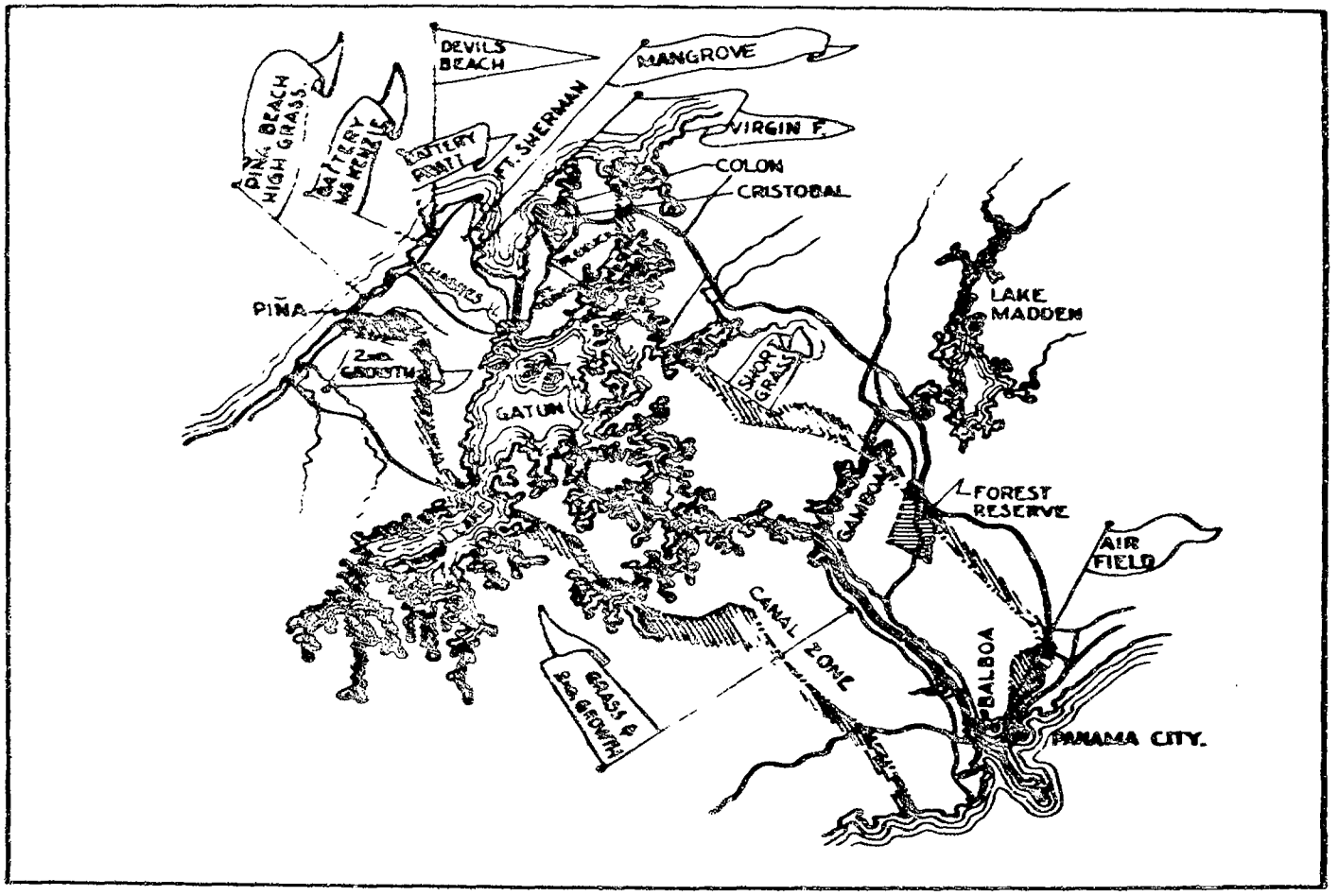


Fig. 1k. Panama Canal Zone, showing location of test areas used.

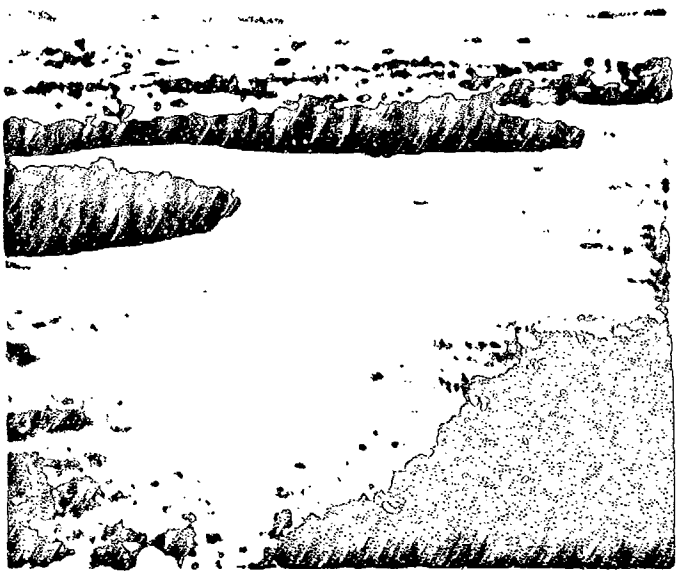
05948

Fig. 15. Typical high ground in the Panama Canal Zone.

Fig. 16. Air view of Chagres River near its mouth, showing the Army ferry landing. Grass area shown is over 6 feet high.

Fig. 17. View of Panama Canal with grass areas near the stream and forest beyond.

Fig. 18. Typical cloud forest in Panama in the vicinity of Chirique. Photograph taken by Sir Hubert Wilkins.



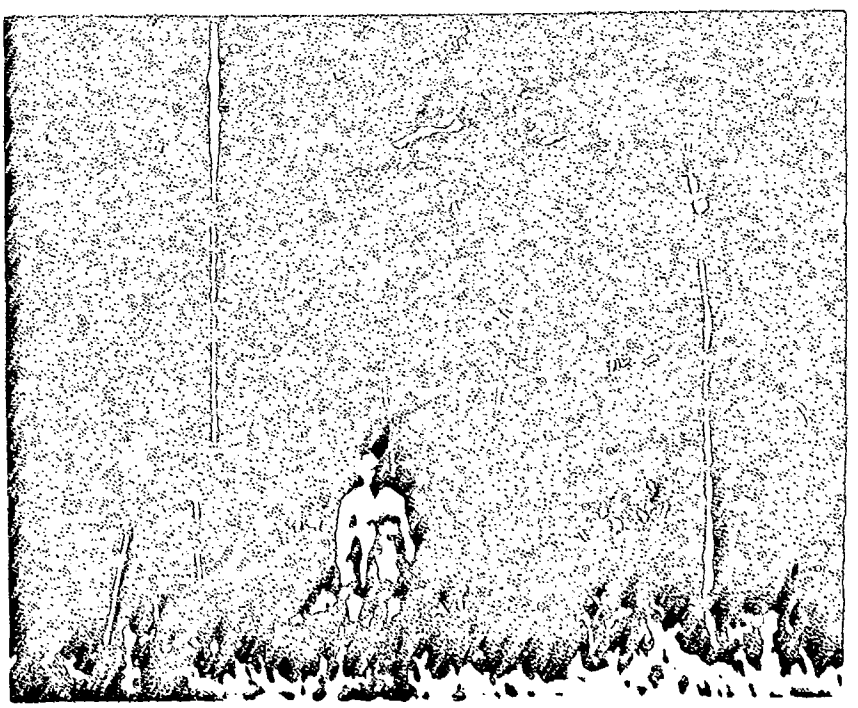


Figure 13 shows the location where observations were made and photographs were taken by Sir Hubert Wilkins in a cloud forest on the slope of Chirique Mountain following the conclusion of the Canal Zone tests.

8. Test Methods. The studies conducted at each of the sites listed above consisted in general of observations under a variety of lighting conditions of live models wearing uniform and equipment ensembles noted below. The observations included those made by visual, photographic, and infrared means. The hot-dry and hot-wet tests are listed separately because of a difference in emphasis and, except for the short grass area, because the comparison of detection ranges in Panama was found to be academic and was, therefore, abandoned.

a. Hot-Dry Terrains. The studies in the desert consisted of a series of observations in which four models proceeded from beyond the threshold of detection to the observers or vice versa, undertaking a variety of maneuvers on signal to permit a comparison of the camouflage provided. Ranges between models and observation point were determined by a 1-meter base range finder, and communication was maintained between models and observers via transceiver radio. There were three series of comparisons made under front, side, and rear lighting conditions, as follows:

(1) Four models, each wearing a uniform of Tan 112, Khaki 1, Green 116, or Olive Green 107, with helmet and auxiliary equipment (less body armor) in standard coloration (olive drab) as issued for all (Fig. 19).

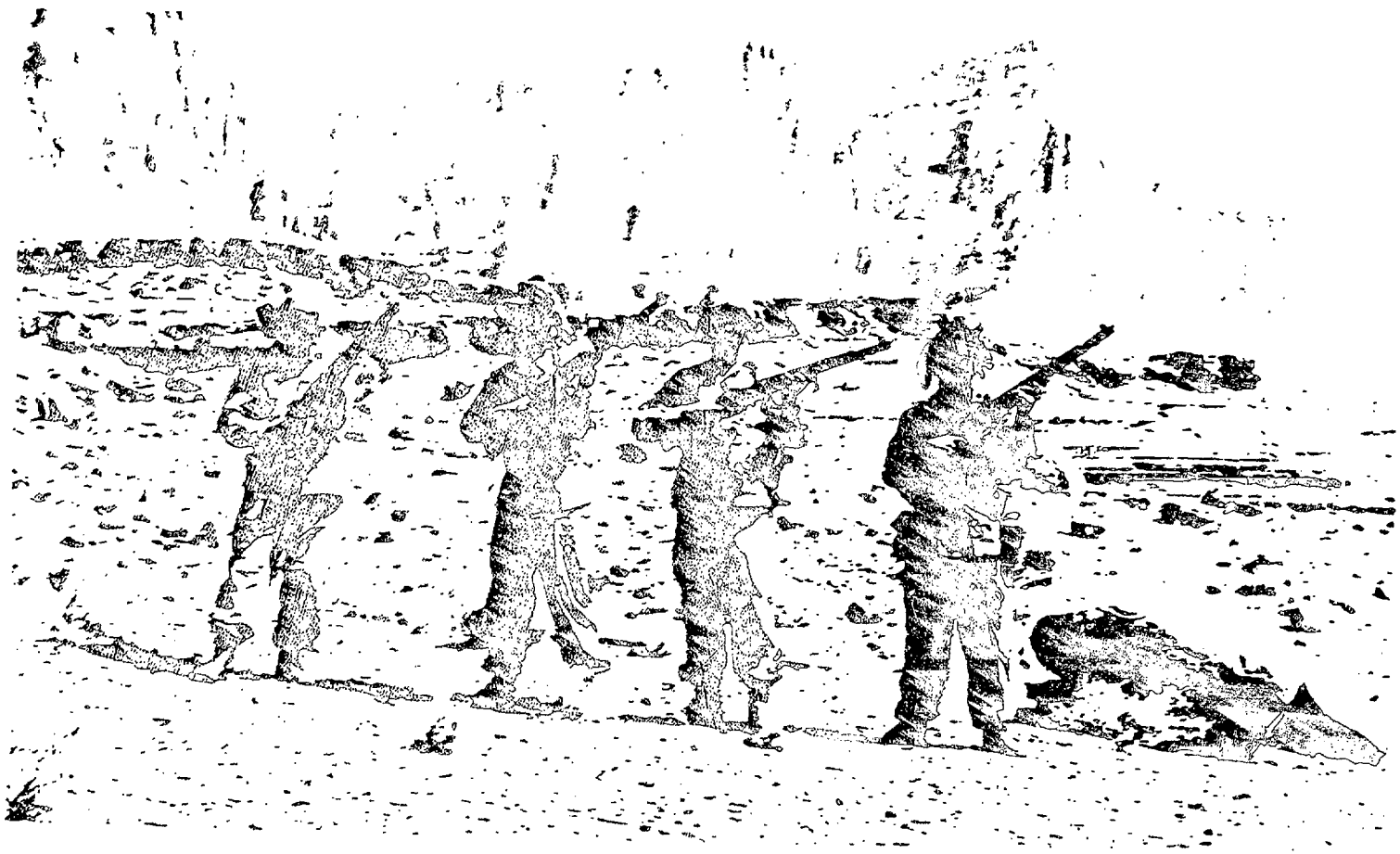
(2) Four models each wearing a uniform in colors specified above with auxiliary equipment including helmet cover (less body armor) in colors matching that of the uniform (Fig. 20).

(3) Four models all wearing Tan 112 colored uniforms with two models in body armor and auxiliary equipment in standard coloration (olive drab) as issued and two models in body armor and auxiliary equipment in Tan 112 to match the uniform (Fig. 21).

The observations of the individual observers were recorded on test record forms, a sample of which is shown in Fig. 22. This form provided for the recording of ranges at which the observer detected each model as an object when standing still, walking, and prone. The form also provided for the recording of those ranges where each model, again in three attitudes, was recognized as a man; those ranges where a color (chromaticity) difference and color identification were determined; and finally, those ranges where the packs and other auxiliary equipment were detected. On the reverse side of the form was a series of questions to be answered, where

A7464

Fig. 19. Models dressed in ensembles used in Desert Test Series No. 1. Photograph taken at Rosamond Site. Colors (left to right) are Olive Green 107, Khaki No. 1, Green 116, and Tan 1:2.

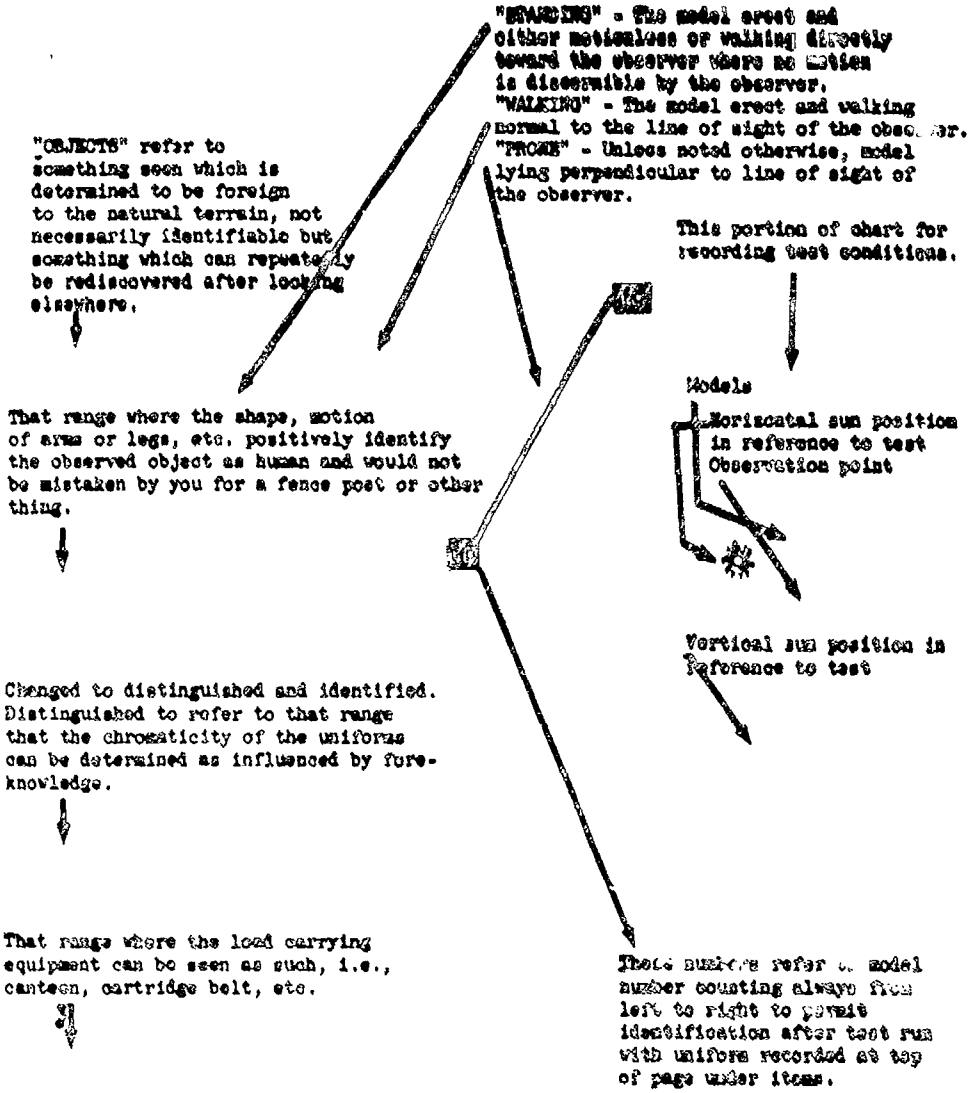


A3358

Fig. 20. Models dressed in ensembles used in Desert Test Series No. 2. Photograph taken near Marble Canyon Site. Colors (left to right) are Khaki No. 1, Green 116, Tan 112, and Olive Green 107.

A3361

Fig. 21. Models dressed in ensembles used in Desert Test Series No. 3. Photograph taken near Marble Canyon Site. Color is Tan 112, with two models in olive-drab body armor, without helmet covers and two models in tan body armor, with helmet covers.


"STANDING" - The model erect and either motionless or walking directly toward the observer where no motion is discernible by the observer.
"WALKING" - The model erect and walking normal to the line of sight of the observer.
"PRONE" - Unless noted otherwise, model lying perpendicular to line of sight of the observer.
"OBJECTS" refer to something seen which is determined to be foreign to the natural terrain, not necessarily identifiable but something which can repeatedly be rediscovered after looking elsewhere.
This portion of chart for recording test conditions.
Models
Horizontal sum position in reference to test Observation point
That range where the shape, motion of arms or legs, etc. positively identify the observed object as human and would not be mistaken by you for a fence post or other thing.
Vertical sum position in reference to test
Changed to distinguished and identified. Distinguished to refer to that range that the chromaticity of the uniforms can be determined as influenced by foreknowledge.
That range where the load carrying equipment can be seen as such, i.e., canteen, cartridge belt, etc.
These numbers refer to model number counting always from left to right to permit identification after test run with uniform recorded at top of page under items.

CAMOUFLAGE DESERT COLOR STUDIES-1953
OBSERVERS DATA RECORD SHEET

To Be Filled In at Conclusion of Observations

ITEMS #1 #2 #3 #4 #5

SITE
TEST NO.
OBS.NO.
DATE
TIME START Hrs
TIME FINISH Hrs

OBSERVATIONS

NO. I DETECTED AS OBJECTS IN YARDS

STANDING	No	WALKING	No	PRONE	No

NO. II IDENTIFIED AS A MAN IN YARDS

STANDING	No	WALKING	No	PRONE	No

NO. III COLOR IDENTIFIED IN YARDS

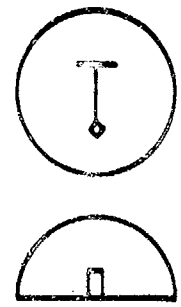
No	ERECT	COLOR	PRONE	COLOR
1				
2				
3				
4				
5				

NO. IV WEBBING DETECTED IN YARDS

No	ERECT	PRONE
1		
2		
3		
4		
5		

ILLUMINATION

BRIGHT SUN
HAZY SUN
SCATTERED CLOUDS
CLOUDY
OVERCAST



NIGHT NO MOON
MOON 1/4 1/2 3/4 F
CLEAR
CLOUDY
OVERCAST

OBSERVER
BIG
Print Name
RANK COMP.
REPRESENTING
OFFICE
LOCATION

See Other Side

Fig. 22. Desert test record form used by observers.

Please answer all questions:

1. What do you consider was the primary factor which permitted your initial detection of the models? (movement, shadow, shine, etc.) _____

_____

_____

_____

2. As a rifleman, which of the items observed would you consider
The best target _____ The poorest target _____ No difference _____

3. As a result of this single observation I would select coloration for the following items as shown. (Colors CD-7; CC-107; Tan-118, Green-116, Khaki)

Item	Color Choice
Uniform	_____
Pack	_____
Body Armor	_____
Belt & Suspenders	_____
Rifle Cover	_____
Helmet or Helmet Cover	_____

4. I would prefer to have the webbing and pack the same color as the uniform:
a. Yes b. No c. Makes no difference

5. As a result of this observation I would conclude that:

	Yes	No
a. A helmet cover is desirable	___	___
b. The Marine Corps types are preferred	___	___
c. No helmet cover is necessary	___	___
d. There is no significant difference between the Marine and experimental types of helmet cover from a concealment viewpoint	___	___
e. The experimental type is preferred	___	___
f. The helmet without cover but properly colored provides sufficient camouflage	___	___
g. The body armor requires specific desert coloration	___	___
h. A rifle cover is desirable	___	___
i. A rifle cover is not necessary	___	___
j. The combat pack requires specific desert coloration	___	___
k. The suspenders & rifle belt require specific desert coloration	___	___

6. As a soldier in an attack on this OP under the conditions of this observation I prefer to be in a uniform of _____ color with webbing and pack in _____ color.

7. Remarks and Suggestions: _____

_____

_____

_____

_____

appropriate, plus a remarks space for comment on points not otherwise covered.

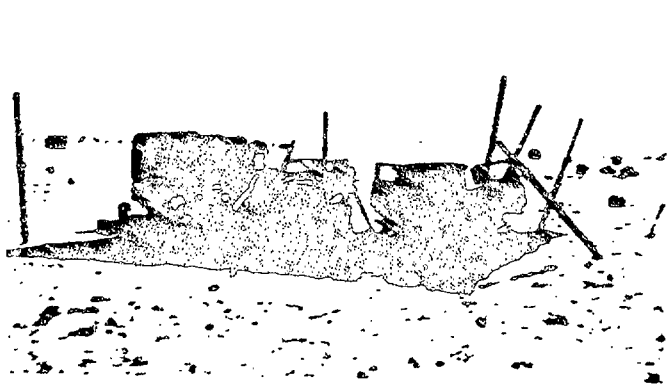
The observers did not know which of the three tests was to be run or the order of ensembles. The observers were given a general direction in which to look and were told when the models had begun their approach. Both an automatic calling out of ranges at each 100 yards and a range given only when requested were used as methods of informing the observers of the models' range. To prevent influencing, no conversation between observers was permitted during an observation. The models were instructed by radio to walk laterally, kneel, lie prone, etc., at various distance ranges and every 100 yards up to 1,000 yards.

A typical observation was conducted in the following manner: The models were transported to a point beyond the threshold of detectability, dressed in one of the sets of uniforms and equipage listed above, and inspected. Meanwhile, the observers arranged themselves as shown in Fig. 23, upper right, and filled in the preliminary data on the record form. The radio operator checked with the models, and the range finder was made ready. When the models were ready, the chief model called the observation point; if the observation point was ready, the models were directed to begin their approach. Range was not given until an observer asked for it, but thereafter the range was given orally by the range finder operator at each 100 yards. (Ranges under 500 yards were paced and marked at each 100 yards.) The models were instructed in maneuver until information required was obtained. The identity of the model's color ensemble was recorded last since the observer was initially denied this information purposely.

Night observations were conducted at two sites--Marble Canyon and Westmorland. The models, dressed as indicated in subparagraph a(2) above, were required to walk away from the observers until they could no longer be detected, then directed to return to the observers. Ranges were determined by pacing and oral request. In this observation, the models were used singly rather than as a group.

Figure 24 is provided to present a pictorial idea of the complexity of the problem and to indicate why a study of this sort is by nature regulated to a broad treatment within the time and importance allotted to such an endeavor. Because of inherent variables occurring in the field, the findings can be expected only to give indicative rather than quantitative results.

b. Hot-Wet Terrains. The three basic tests or observation sequences described for the hot-dry terrains were repeated in Panama except that two additional models were available to permit the evaluation of patterned and RPS-1 green colored uniforms



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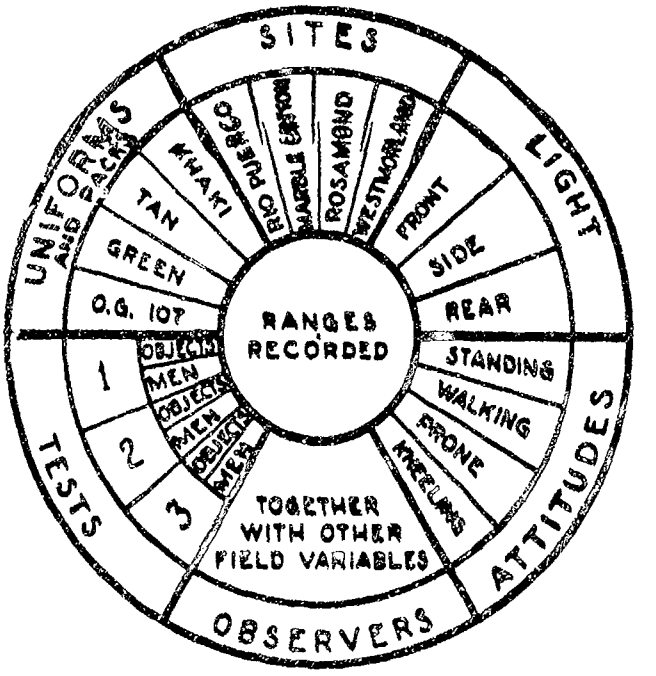
A7559

Fig. 23. Typical observation. Upper left: Observation point (radio carried in 3/4-ton truck). Upper right: Observation crew (left to right)--Hopkins, Kirby, Lt Pusey, Hannigan, Sgt Harp, and Sir Hubert Wilkins (photographer not shown). Bottom left: Sgt Adcock inspecting models (note radio carried by third model from left). Bottom right: Models at 600-yard range during observation run.



VALID COMPARISON OF RESULTS UNDER ANY OF ABOVE HEADINGS (OF RANGES RECORDED) REQUIRES THAT OTHER VARIABLES BE EQUATED

Fig. 24. Major variables inherent in desert color studies, 1953.

(Fig. 25). No attempt was made to evaluate or record the detection ranges during these tests since they were extremely variable and of no real significance in these highly vegetated areas. The problem was primarily one of relative conspicuousness, i.e., eye-catching contrast. Therefore, the findings were based upon an objective analysis of the order of conspicuousness and a subjective judgment of the degree of advantage or disadvantage gained by various coloration combinations. At each test site, both attack and defensive attitudes were assumed by the models. These attitudes included route march; approach by walking, creeping, and crawling; and concealed and unconcealed stationary positions.

In addition to the above, the procedure for recoloring and patterning a uniform in the field with an experimental spray can colorant (Fig. 26) was explored at Battery Pratt and near Miraflores Lake on the west side of the Canal with observations made in both places to compare the treated uniform with the other uniforms.

Both day and night observations were made, and photographs were taken (through the sniperscope) of the uniforms used in the above described tests plus a set of five test uniforms of varying infrared reflectance, as shown in Table II.

Table II. Infrared Reflectance of Test Uniforms

Uniform	Photo Reflectance IR film w/Wratten 25 filter	Sniperscope Reflectance w/2540 filter
75 S	10.2	11.4
100 S	12.6	13.8
150 S	17.5	19.6
200 S	22.5	25.6
250 S	26.0	32.8

The photography through the sniperscope was accomplished in the following manner: A mounting devised by the Camouflage Branch was used to mount a 4x5 speed graphic camera to the rear of the sniperscope from which the rear ocular lens had been removed. A 35-millimeter focal-length lens with an effective aperture of approximately 3.5 was used in the camera. This permitted the direct recording of the phosphor surface of the image tube with a resultant image magnification of approximately eight times. To obtain enough illumination to record an image, a GE Photoflash TH 50 photographic flash bulb with a total rated output of 9,400 lumen seconds and a peak of 5,200,000 lumens was flashed in a chrome photographic reflector from a distance of 15 to 30 feet from the models. The reflector was held by a person lying on the ground in front of

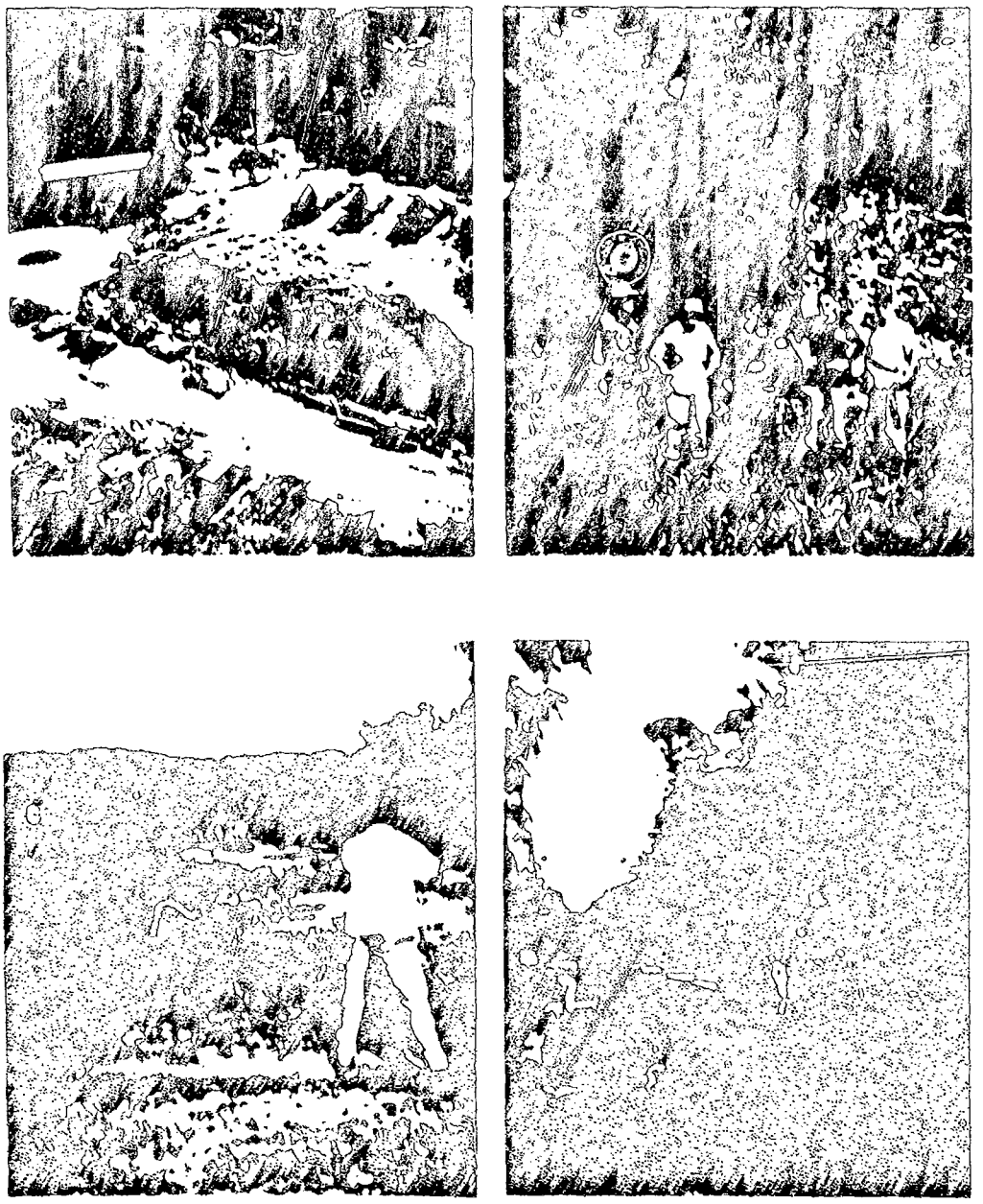
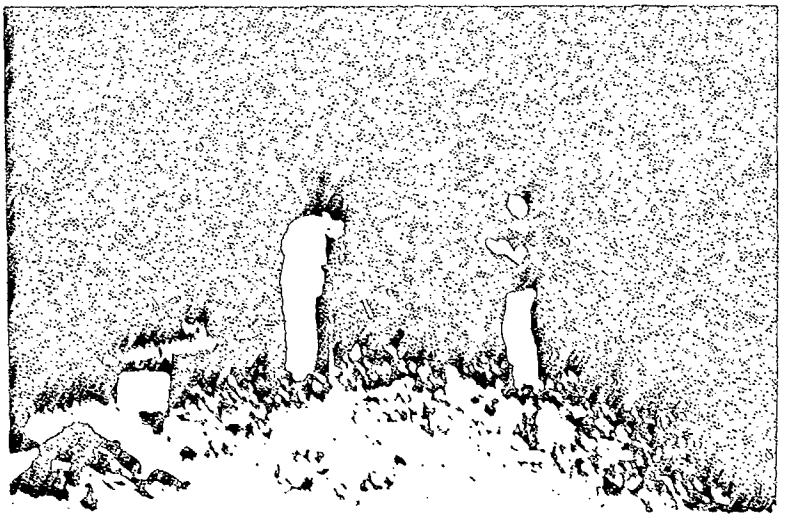
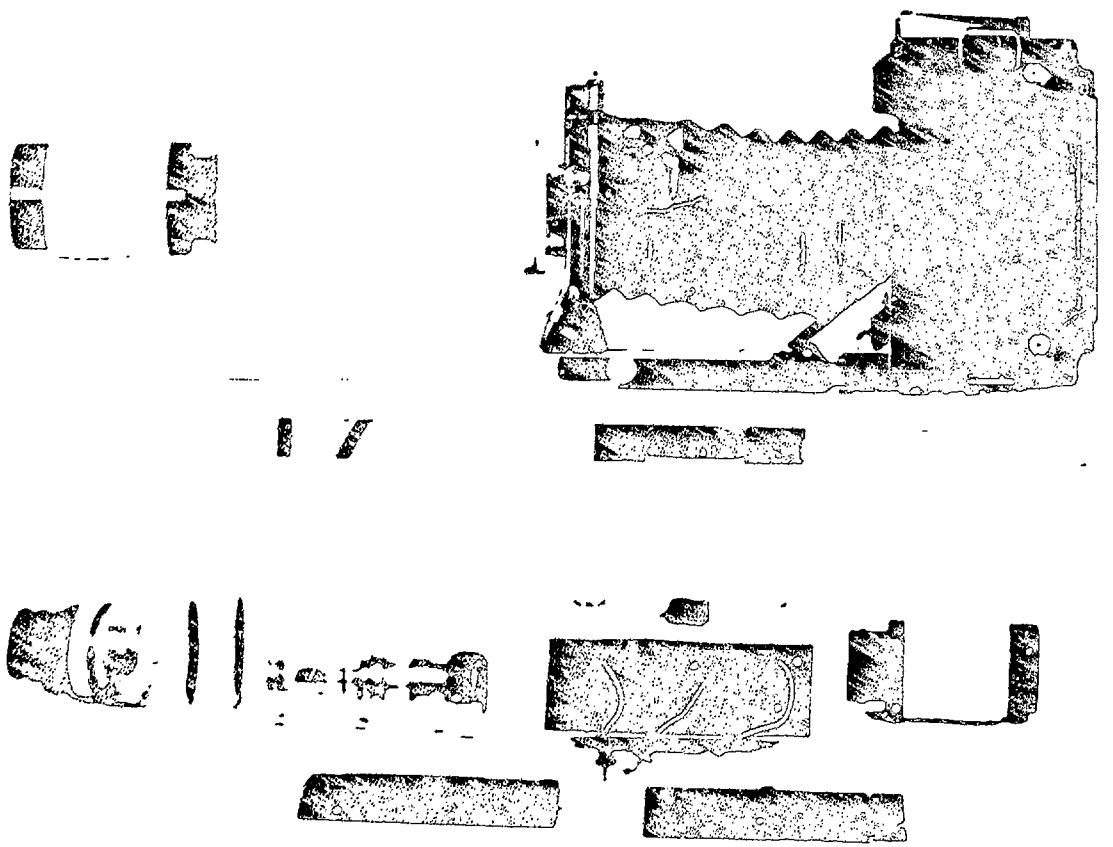


Fig. [illegible] Hand-held spray gun to pattern a Green 11C hot-wet uniform. Pattern scored by visual tests on experimental type wire mesh.



A75-3

Fig. [illegible] Test objects for detection. Tank over (left) alpha-like [illegible] photographic mat. A-1 tent (right) resembling [illegible] photographic hut. Note light [illegible] ground. Model is similar but not road.)



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A8157

Fig. 28. Photographic sniperscope unit. Top: Assembled unit ready for field use. Bottom: Disassembled unit less camera, showing optics and image tube. (Designed by A. Willis, Camouflage Branch, ERDL.)

and in line with the sniperscope. A Wratten 89 filter over the objective lens of the sniperscope permitted only the infrared radiation to reach the image tube. Figures 27 and 28 show the system in detail.

c. Photographic Coverage. Photographic coverage of these tests included 16-millimeter Kodachrome motion pictures; panchromatic, infrared, and color aerial and ground still photographs; and 35-millimeter stereopair color photographs of many phases of the tests and terrain of special interest. In addition to the sites listed in paragraph 7, coverage of static observations were made of the models in sand dunes west of Yuma, Arizona; in thick brush 10 miles north of Adelanto, California, on Route 395; and in the vicinity of Vermellion Cliffs Court on Highway 89 in Northern Arizona.

9. Test Results. The test results are presented in summary form. Tabulation of the recorded ranges taken from the test record forms are to be found in Appendix C, Tables VII through XXII. Spectrophotometric reflectance and chromaticity data are presented in Appendix D, Figs. 60 through 64.

a. Hot-Dry Terrains. A summary tabulation of the tests conducted at the four primary sites is presented in Fig. 29. Figures 30 through 38 depict the results of the threshold tests. The results are presented in photographic form to provide a visual comparison of the various overall effects of lighting, model attitude, site, and color combinations upon detectability of personnel. When this data is used, it is important to bear in mind that the ranges obtained through these tests are indicative of relationships and are not quantitative except within a single observation sequence. These ranges are, therefore, to be taken as generalizations only, since the observations were made over limited terrains by a relatively few persons possessing considerable foreknowledge and with atmospheric attenuation (visibility) conditions uncontrolled except in a broad way. One important aspect which is not indicated by these diagrams is the relative conspicuity of the color ensembles tested. This aspect is covered under subparagraph 9a(7).

(1) Detection as Objects Foreign to the Terrain. The results of threshold detection and identification, Blocks I and II on the test record form, are shown in Figs. 39 through 44. Of the six bar graphs presented, two are devoted to each of the three test series in order. The diagrams are divided into three main sections: standing, walking, and prone, with the kneeling attitude indicated for the tests at Marble Canyon Site. (The foliage cover was so high at Marble Canyon that effective observation of the prone attitude was denied.) These sections are further divided into the three lighting conditions

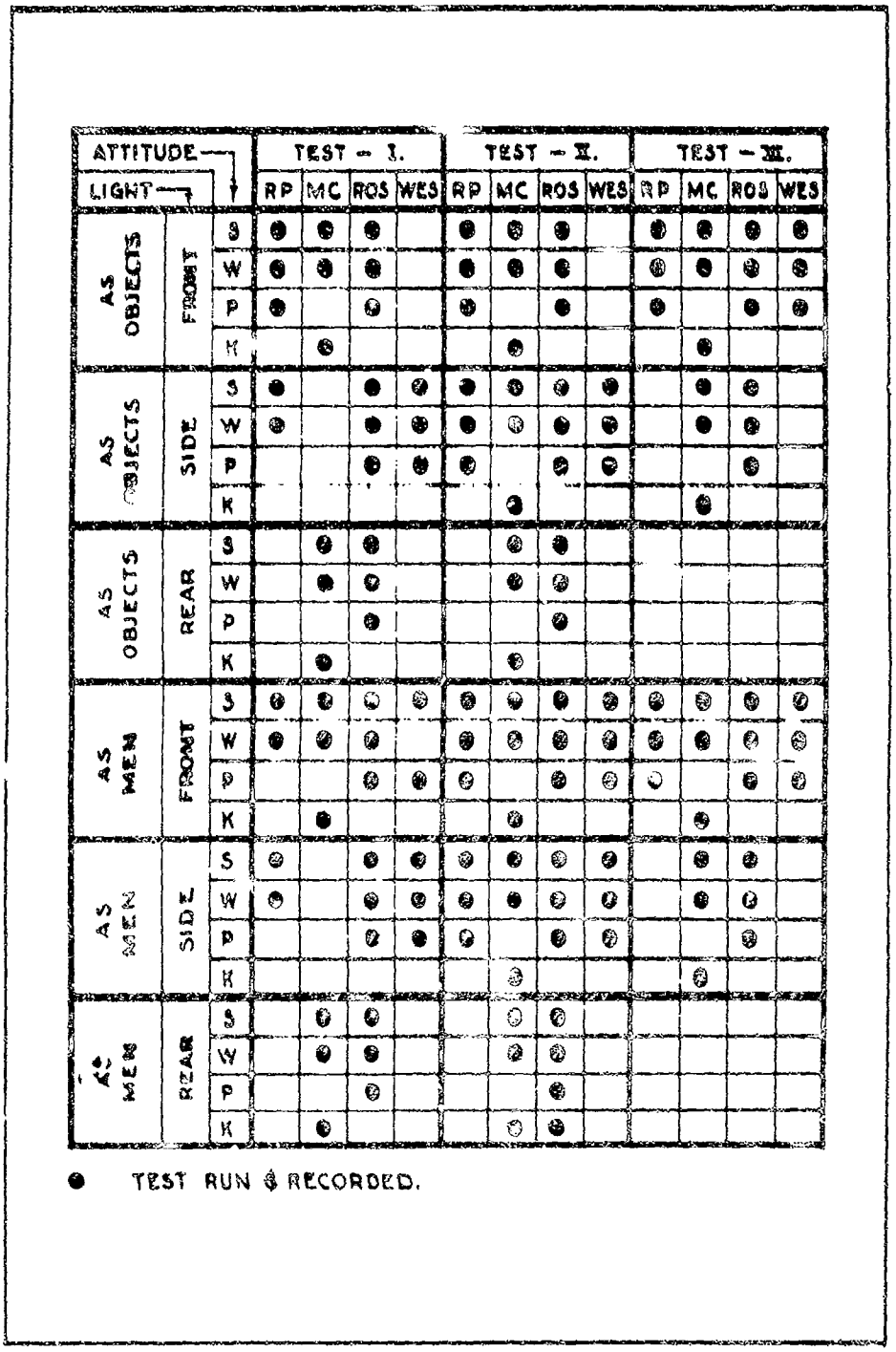

Fig. 29. Tests accomplished.

under which the tests were run and these, in turn, into the sites and, finally, the uniform color ensembles tested. Each vertical bar representing one particular uniform depicts at the top the farthest range recorded, and at the top of the cross-hatched portion, the range at which all observers made their detection. The average detection range for each bar is denoted by the heavy bar.

Even cursory examination of these charts reveals that there is an advantage in the light colors, Khaki and Tan. More careful study indicates that this advantage is increased under conditions that permit extreme uninterrupted observation as found at Rosamond Site. Where lower visibility, hot unstable air, cloud shadow, foliage, rocks, etc. aid in concealment, the detection range average is lower and the differential or advantage is generally lower. Without visibility data, overall comparison of the test series is not too valid. Two points stand out as important, however. The first is that the advantage of the tans over the dark olive colors was more pronounced in the second test than in the first. The additional camouflage afforded by the treatment of the helmets and load carrying equipment is believed to have produced these results. The second point is that under the observation procedures used in these tests the detection of one model by the observer so enhanced the detection of the others that even small differences of detection threshold indicated in results of Test Series No. 1 and 2 are significant from a practical view. A comparison of overall thresholds from Test Series No. 1 and 2 and from Test Series No. 3 are convincing proof of this. The fact that all models in Test Series No. 3 were in tan made the initial detection of the group much more difficult even with dark body armor on two of the models. These indications are important when coloration is applied to fighting units. The whole unit becomes increasingly vulnerable as a few individuals become increasingly detectable, since once seen they locate or fix the locale of search and enhance the detection of their companions.

The charts also indicate a considerable variance in observer capability. While the charts show that one of the observers saw each of the models at some extreme range, it is not necessarily true that all models were seen simultaneously by the same observer. This is one of the pitfalls of graphical summaries. However, observer ability plays a major role in producing comparable results; to determine, therefore, if the observer variance was random or consistent, the records of five of the test observers were compared. Only those observations in which all five observers were present were used in the comparison. The examination showed that the differences were consistent between the observers; in overall comparison of 78

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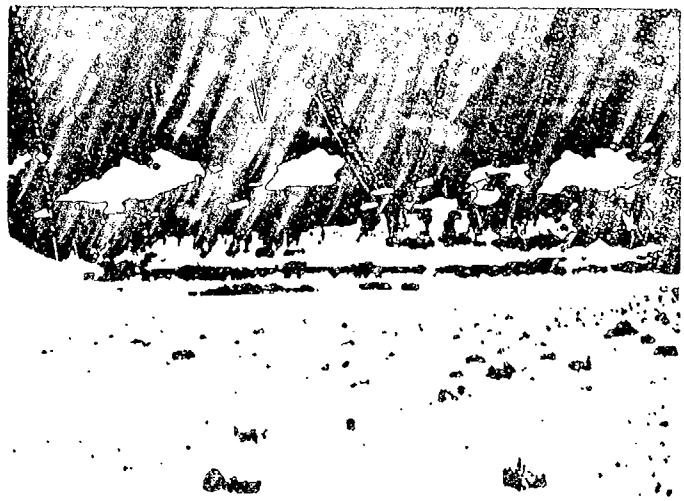
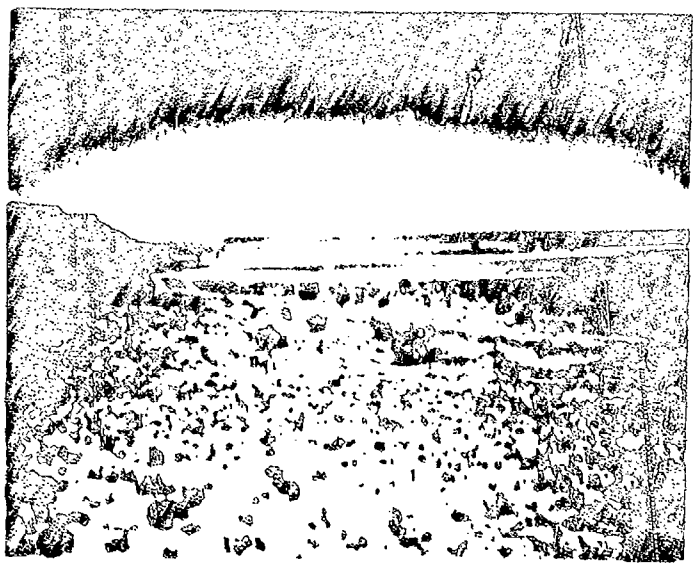
Fig. 30. Desert Test Series No. 1. Top: Models at 400 yards, at Marble Canyon Site; front lighting. Bottom: Models at 600 yards, at Rio Puerco Site; side lighting.





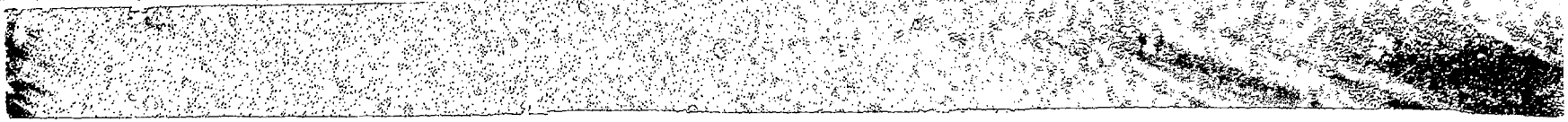
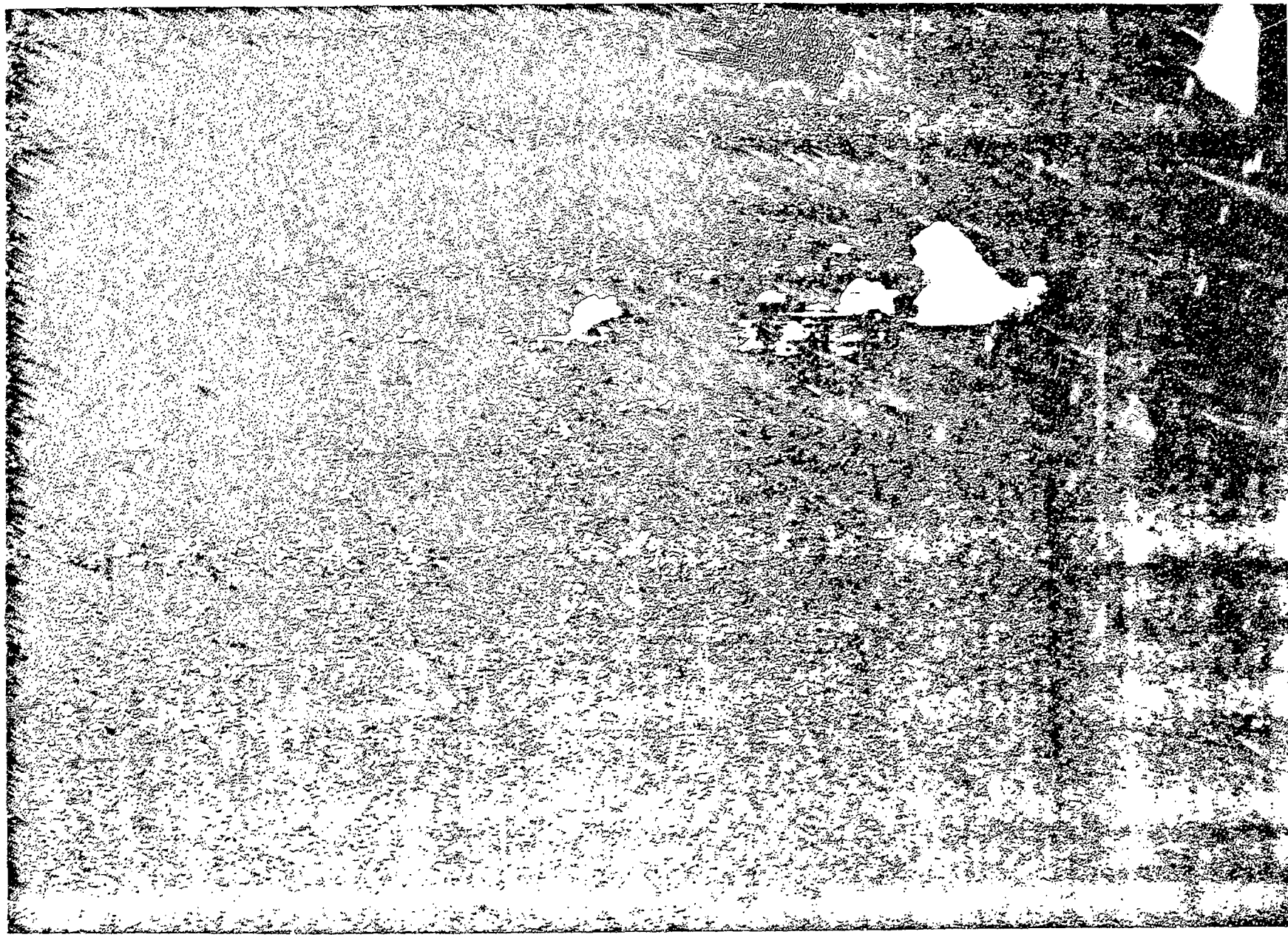


Fig. 31. Hot-dry (desert) coloration effects, Test Series No. 2, Marble Canyon Site, 300-yard range, front lighting. Models left to right: Olive Green 107, Tan 112, Green 116, and Khaki No. 2.



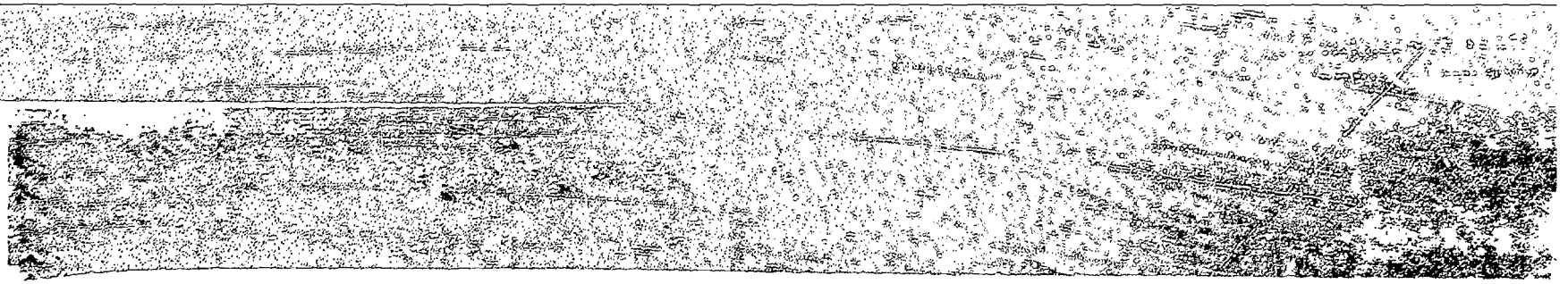
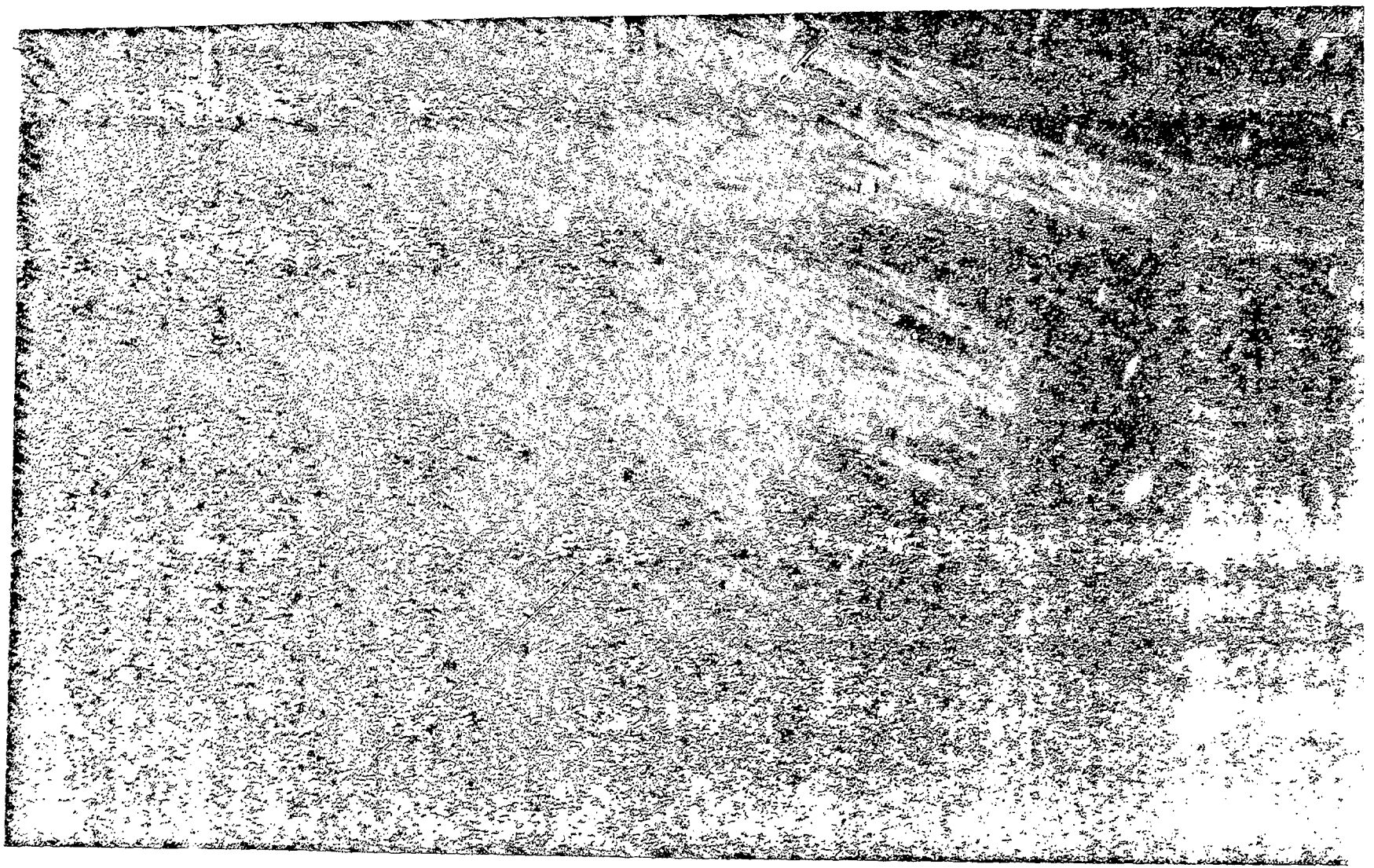


Fig. 31. Hot-dry (desert) coloration effects, Test Series No. 2, Marble Canyon Site, 300-yard range, front lighting. Models left to right: Olive Green 107, Tan 112, Green 116, and Khaki No. 1.



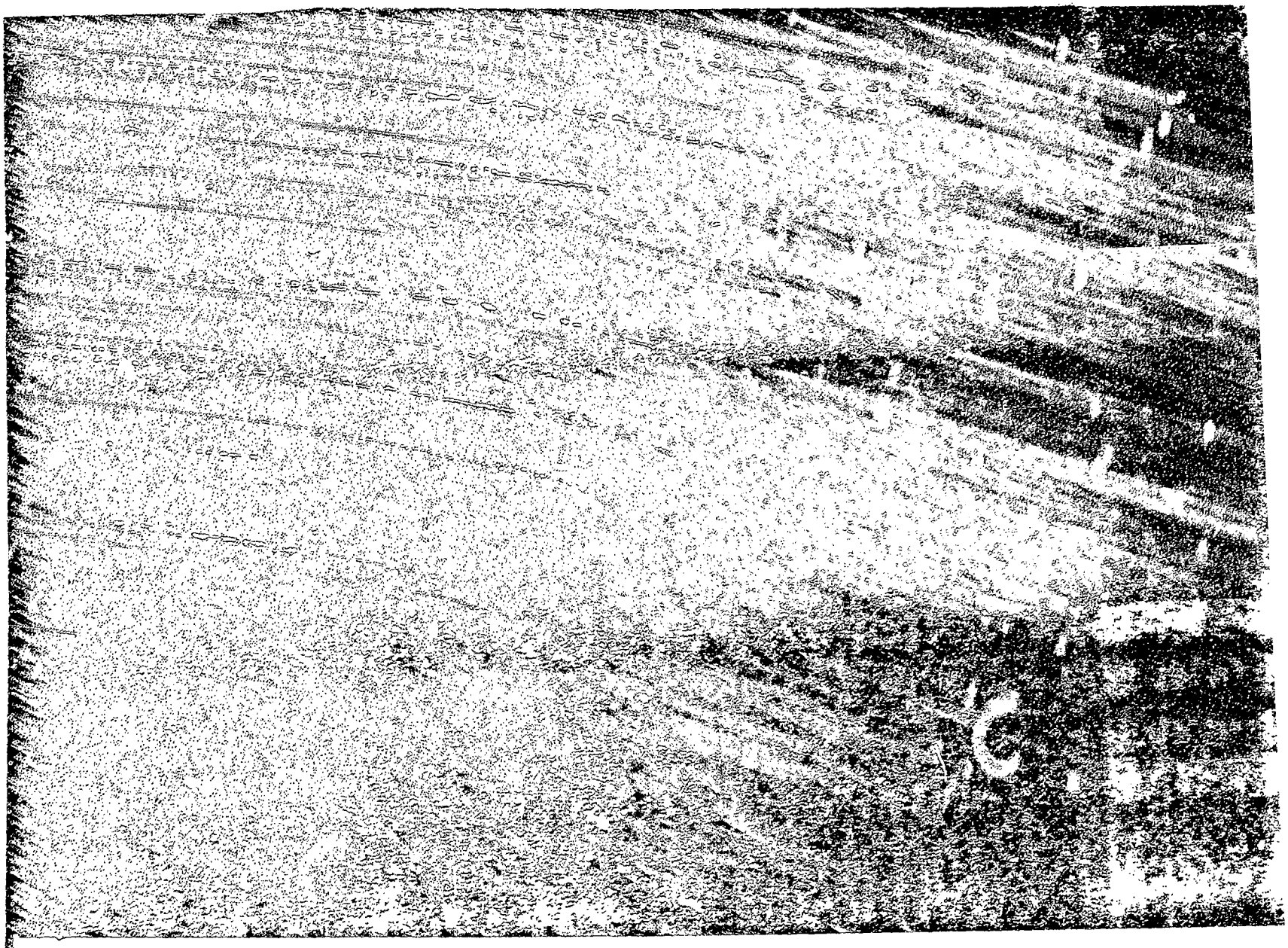


Fig. 31. Hot-dry (desert) coloration effects, Test Series No. 2, Marble Canyon Site, 300-yard range, front lighting. Models left to right: Olive Green 107, Tan 112, Green 116, and Khaki No. 1.

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Fig. 32. Desert Test Series No. 2. Top: Models at 400 yards, at Rio Puerco Site; side lighting. Bottom: Models at 100 yards, at Marble Canyon Site; front lighting.

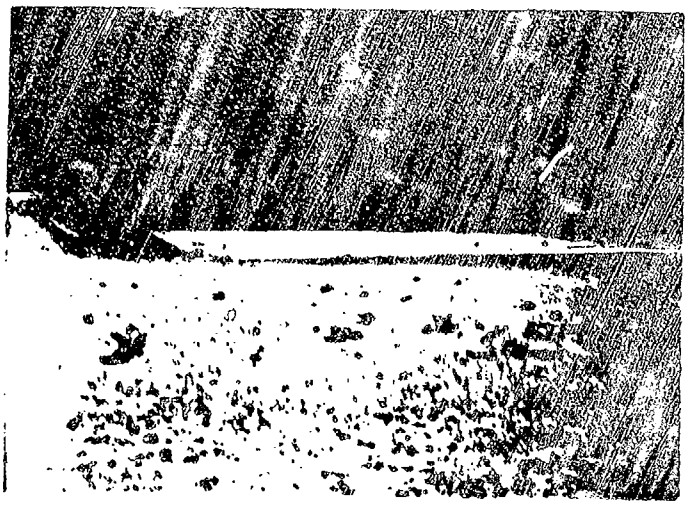
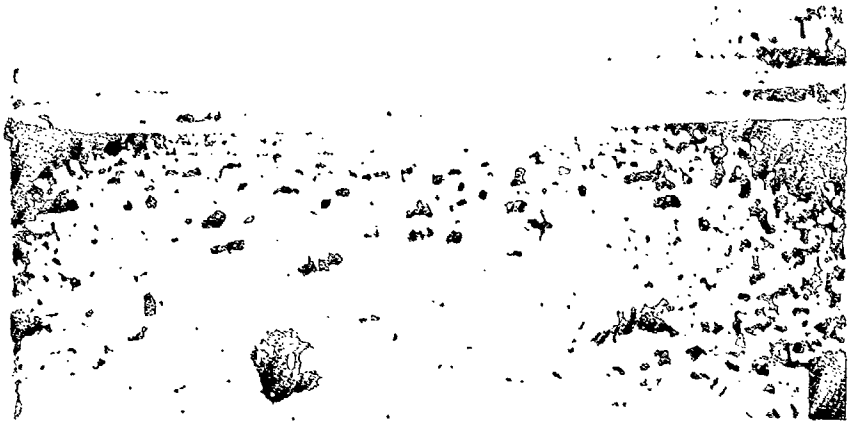


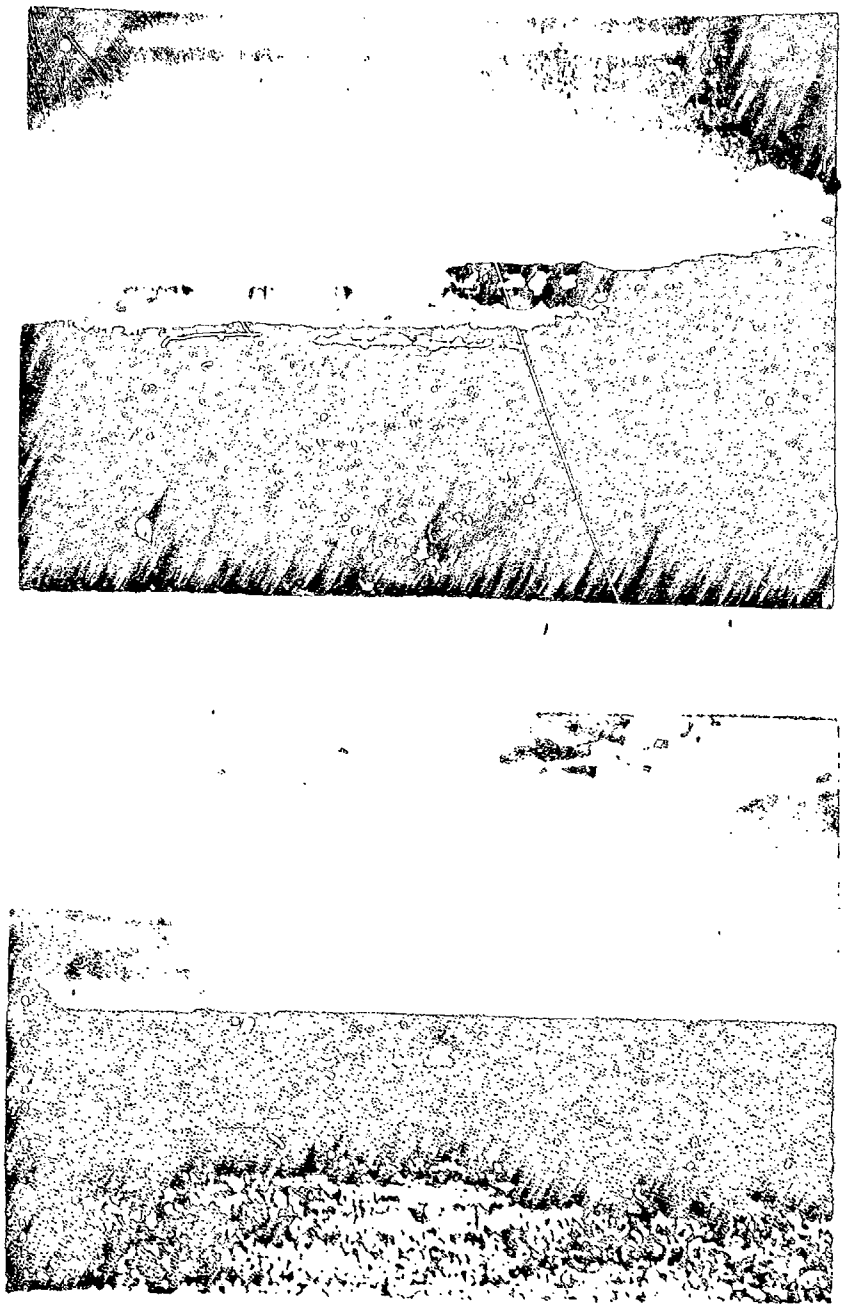
Fig. 33. Desert Test Series No. 9. Top: Models at 150 yards, at Rio Puerco Site; front lighting; No. 2 and 4 wearing olive-drab body armor. Bottom: Models at 100 yards, at Marble Canyon Site; front lighting; No. 1 and 3 wearing olive-drab body armor.



A7599

A7577

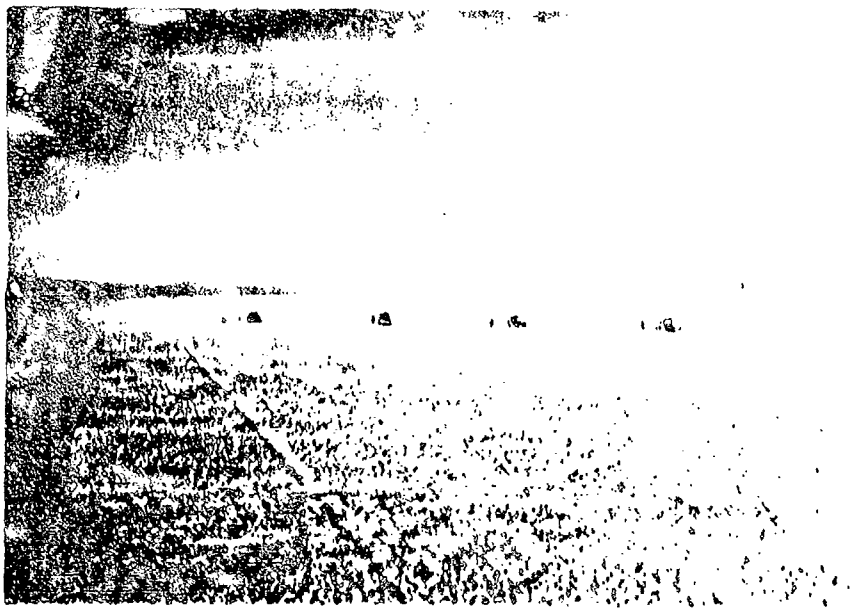
Fig. 34. The kneeling position. Top: Marble Canyon Site; Test Series No. 2; back lighting. Bottom: Rio Puerco Site; Test Series No. 2; overcast lighting.



A7455

A3357

Fig. 35. The prone position. Top. Models dressed in Test Series No. 3 ensembles with two left models wearing olive-drab body armor. Note the dark shadow under raised chest of second model from left. Photograph taken at Rosamond Site. Bottom: Models dressed in Test Series No. 2 ensembles; overcast lighting. Photograph taken at Rio Puerco Site.



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05954

Fig. 36. Mirage effects. Top: Mirage doubling the apparent size of the models. Note the inverted image beneath the models. Bottom: By visually following the tracks in line with arrow, the doughnut hole around the black hole of the 3/4-ton truck which seems to be off the ground may be seen.

05955

A7560

Fig. 37. The effects of rear lighting. Top: Models at 100 yards, Rosamond Site, Test Series No. 2. Bottom: Models at 500 yards, Marble Canyon Site, Test Series No. 2.

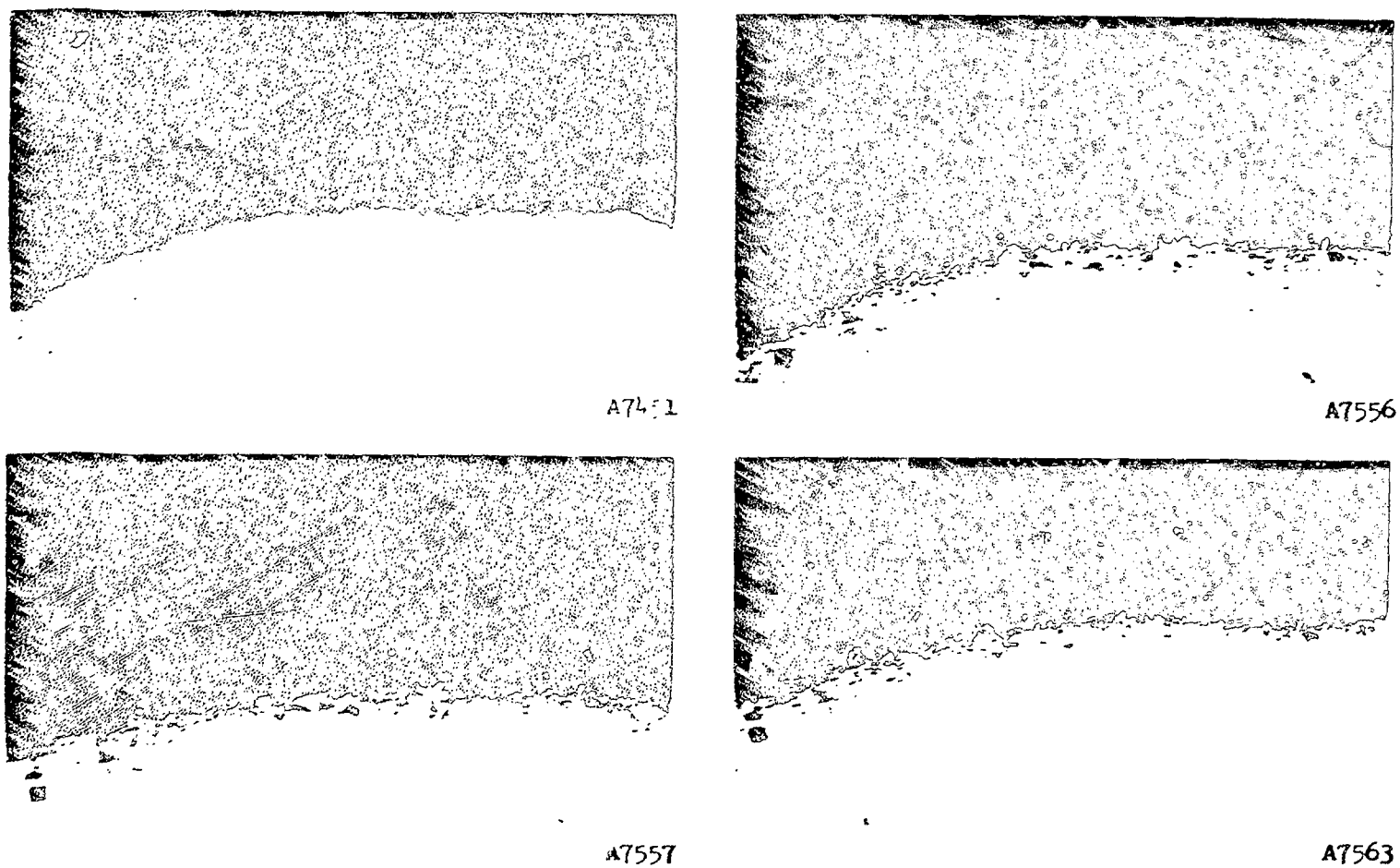


Fig. 38. The effects of horizontal beamed light on detectability of uniforms. In this situation, the dark colors are superior.

observation series, the divergence of each from a mean average was as shown in Table III.

Table III. Comparison Data of Observer Capabilities

Observer	Total of Ranges Recorded	Raw Average	Mean	Difference	Percent
Wilkins	94,640	1213.3	1126.6	86.7	+7.69
Pusey	88,040	1128.7	1126.6	2.1	+1.86
Hopkins	87,400	1120.5	1126.6	6.1	-5.41
Hannigan	77,760	996.9	1126.6	129.7	-11.51
Kirby	91,700	1175.6	1126.6	49.0	+4.35

These results show that Pusey's observer capability was near average, Wilkins' was by far the best, and Hannigan's was the poorest. This indicated that experience in search as well as keen eyesight is an important factor in detection.

A similar examination of results was made to compare the effects of terrain on detection. If the test sites are compared from the standpoint of foliage cover, consistency of ground pattern, and type of distant background on the hypothesis that the more barren and consistent the terrain the easier the search and recognition problem becomes, the test sites rate as follows:

(a) Rosamond. Barren, flat and consistant pattern with background consistency of dark or light line against distant low hills or sky.

(b) Rio Puerco. Nearly barren foreground, flat but some ground patterns evident, background of scattered trees at midrange and lone highlighted horizontal terraces in distances.

(c) Marble Canyon. Considerable patch grass and knee-high brush, flat and uninterrupted terrain with broken patterns of cliffs in distant background.

(d) Westmorland. Widely scattered brush of large clump size, appearing flat to casual observation, but in reality rolling and deeply eroded, causing men to appear, disappear, and reappear in different lines of sight.

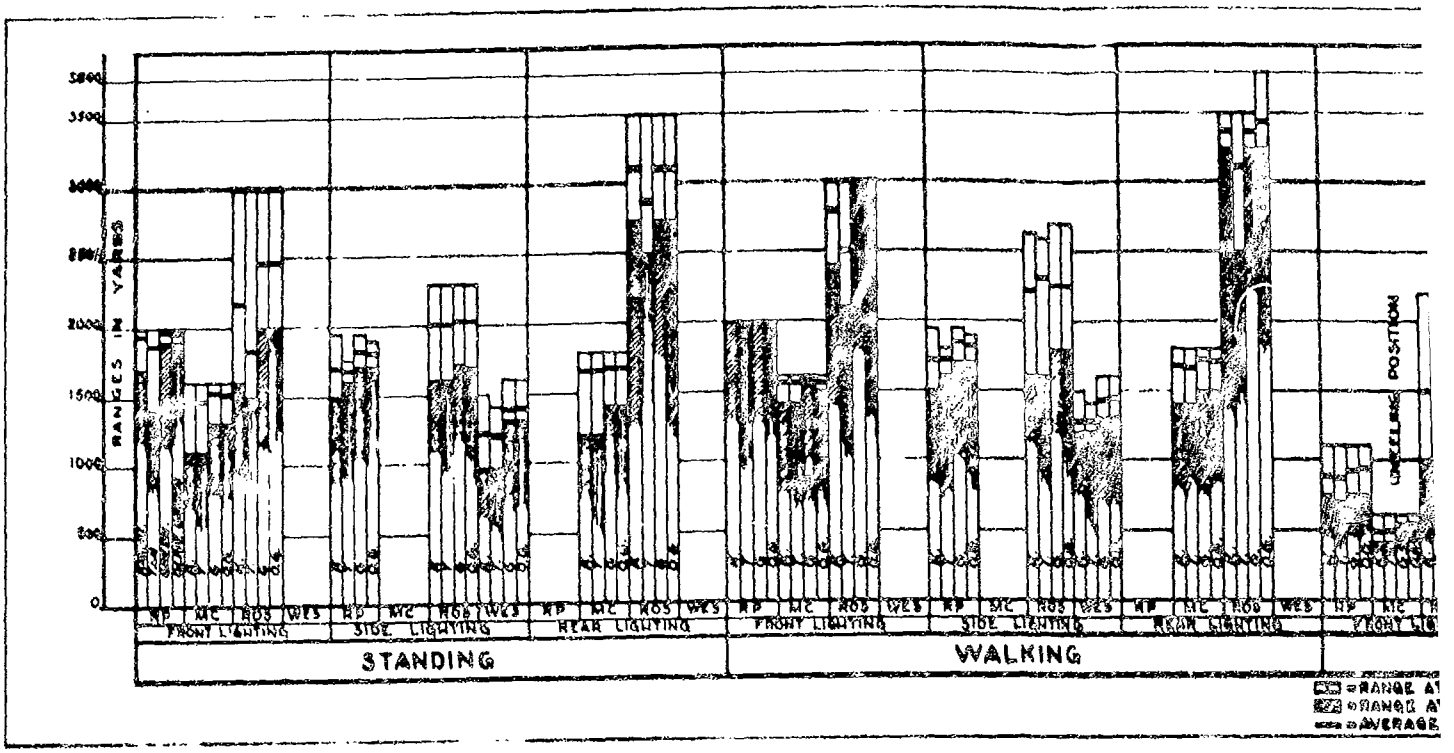


Fig. 39. Results of Test Series No. 1, models detected as objects for terrain. All models in olive-drab load carrying equipment.

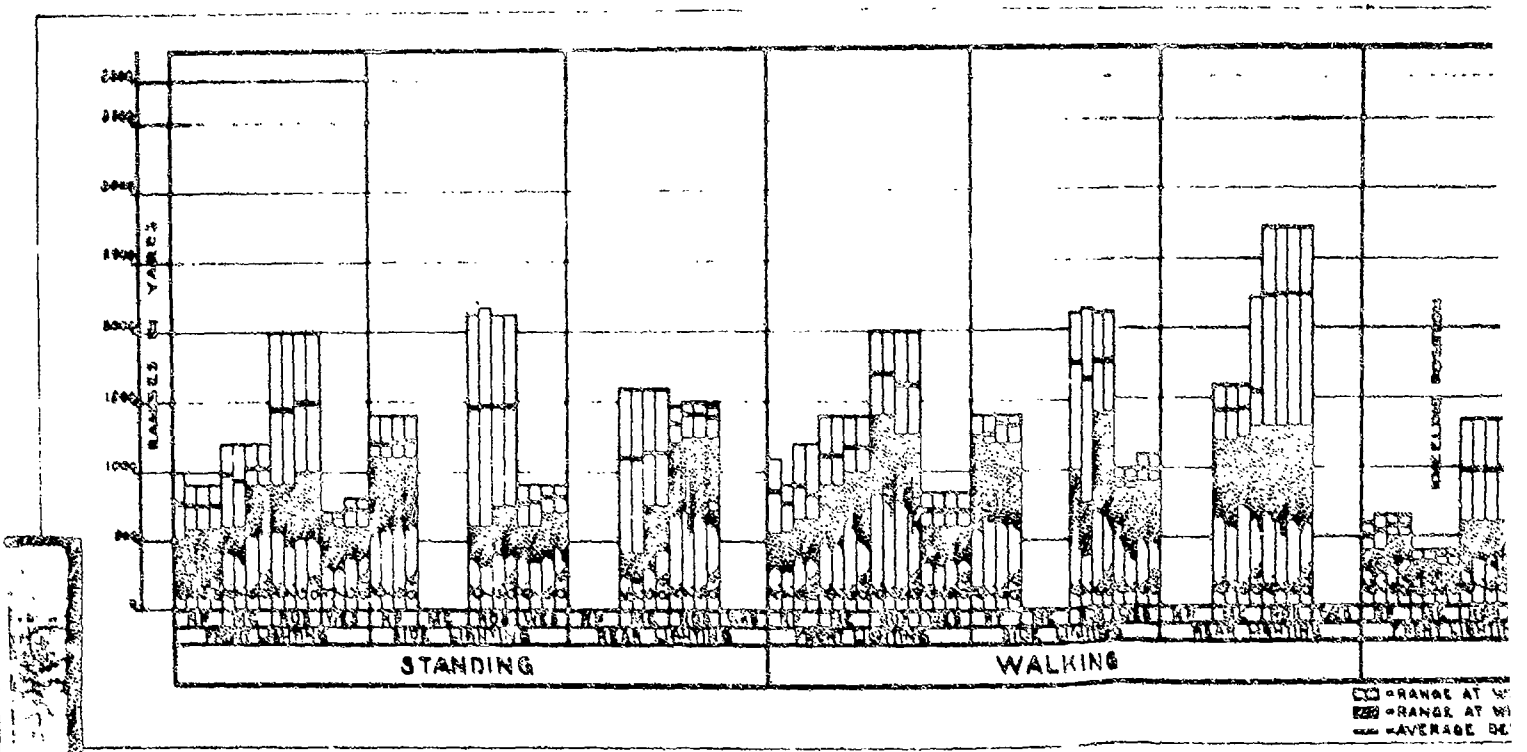
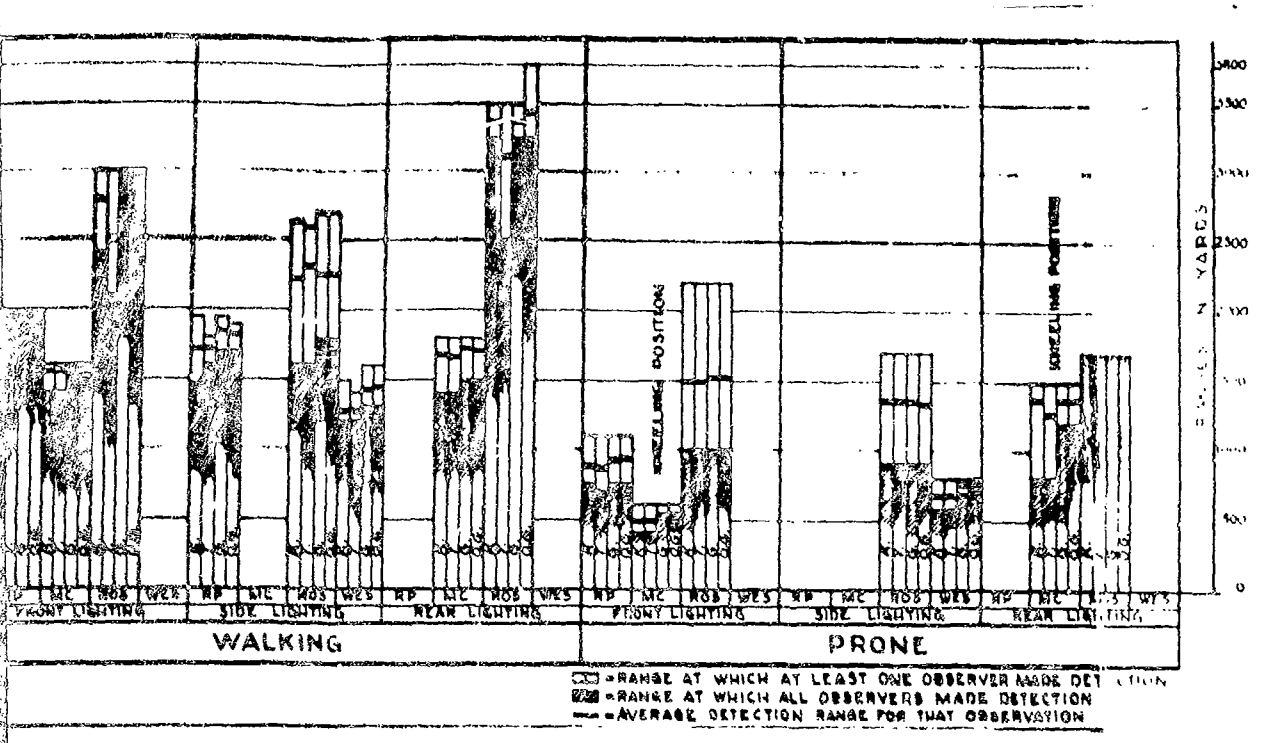
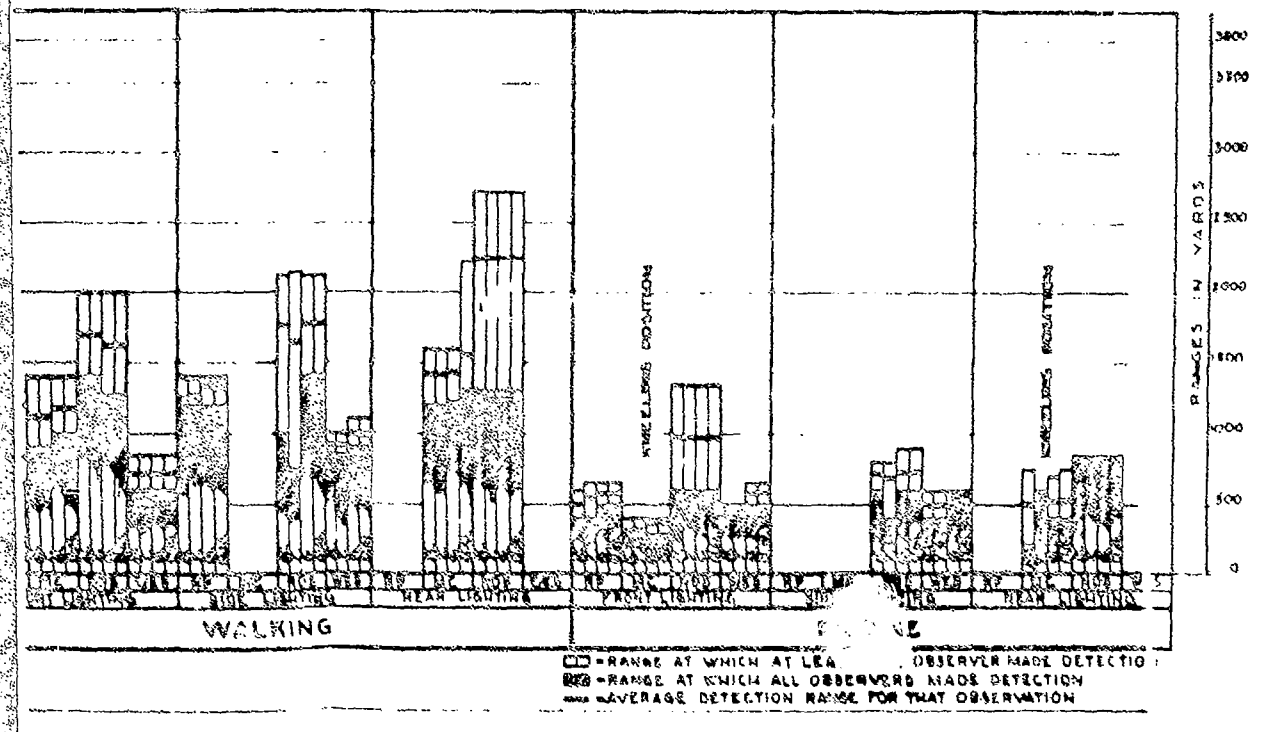


Fig. 40. Results of Test Series No. 1, models identified as men. All m olive-drab load carrying equipment.



...at Series No. 1, models detected as objects foreign to the
... olive-drab load carrying equipment.



...t Series No. 1, models identified as men. All models in
... equipment.

2

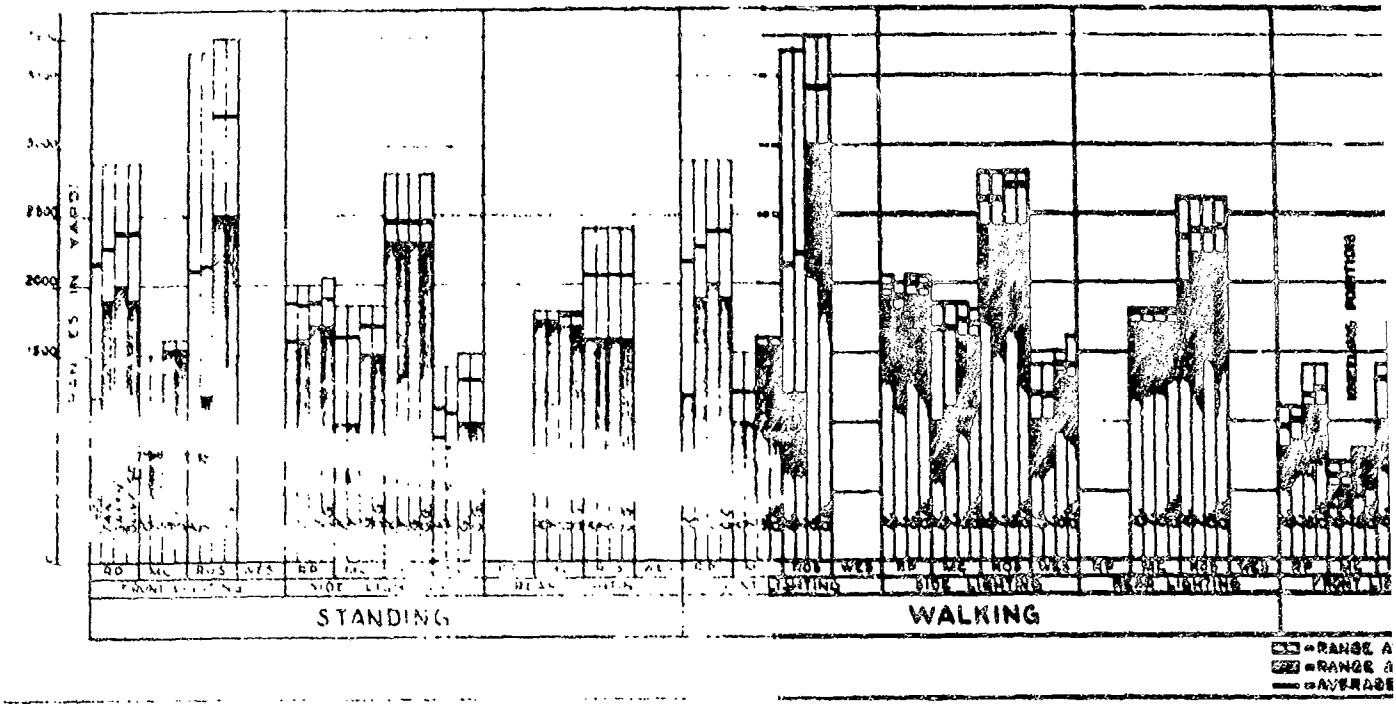


Fig. 41. Results of Test Series No. 2, models detected as objects forei
terrain. All models wearing matching colored load carrying equipment an

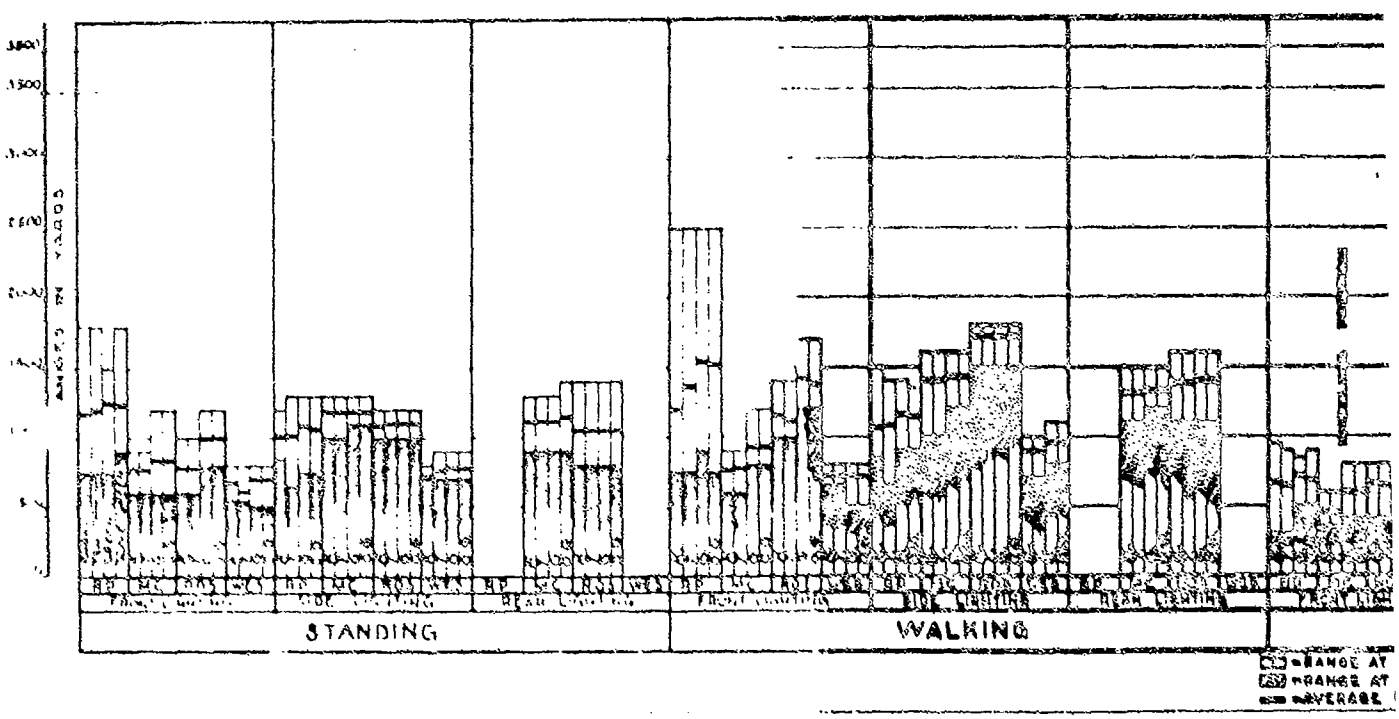
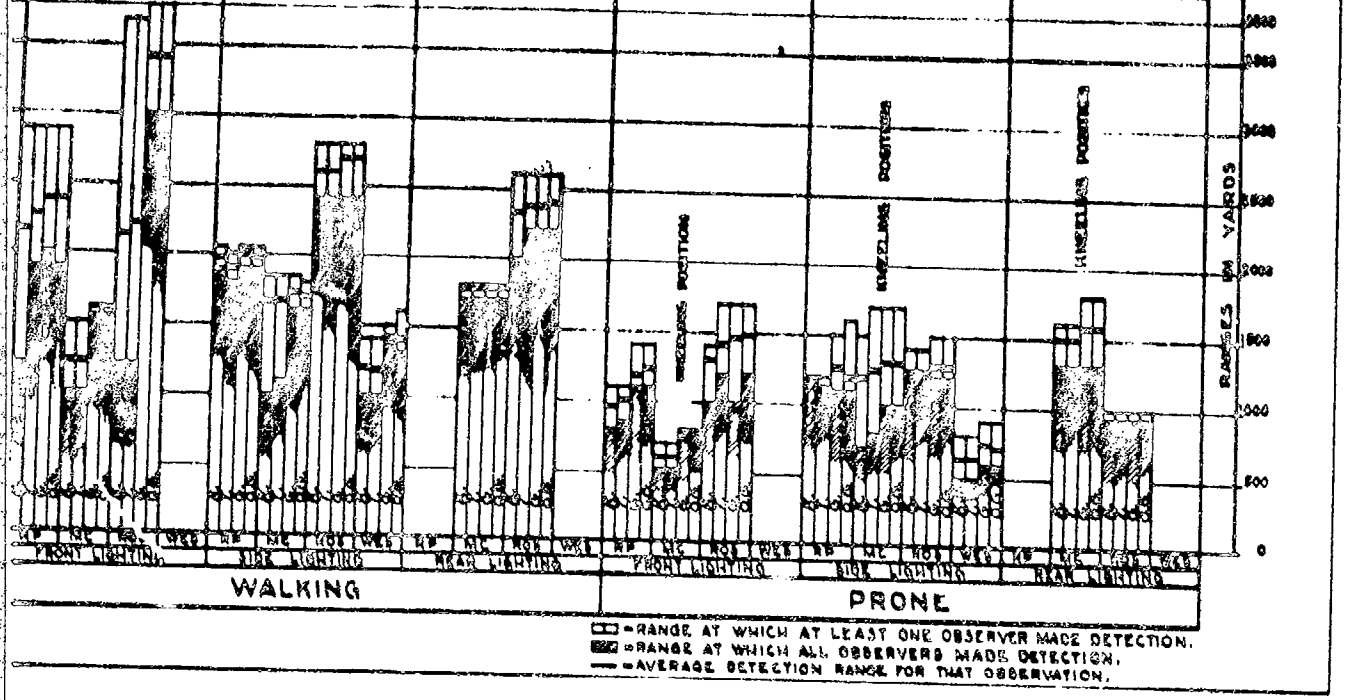
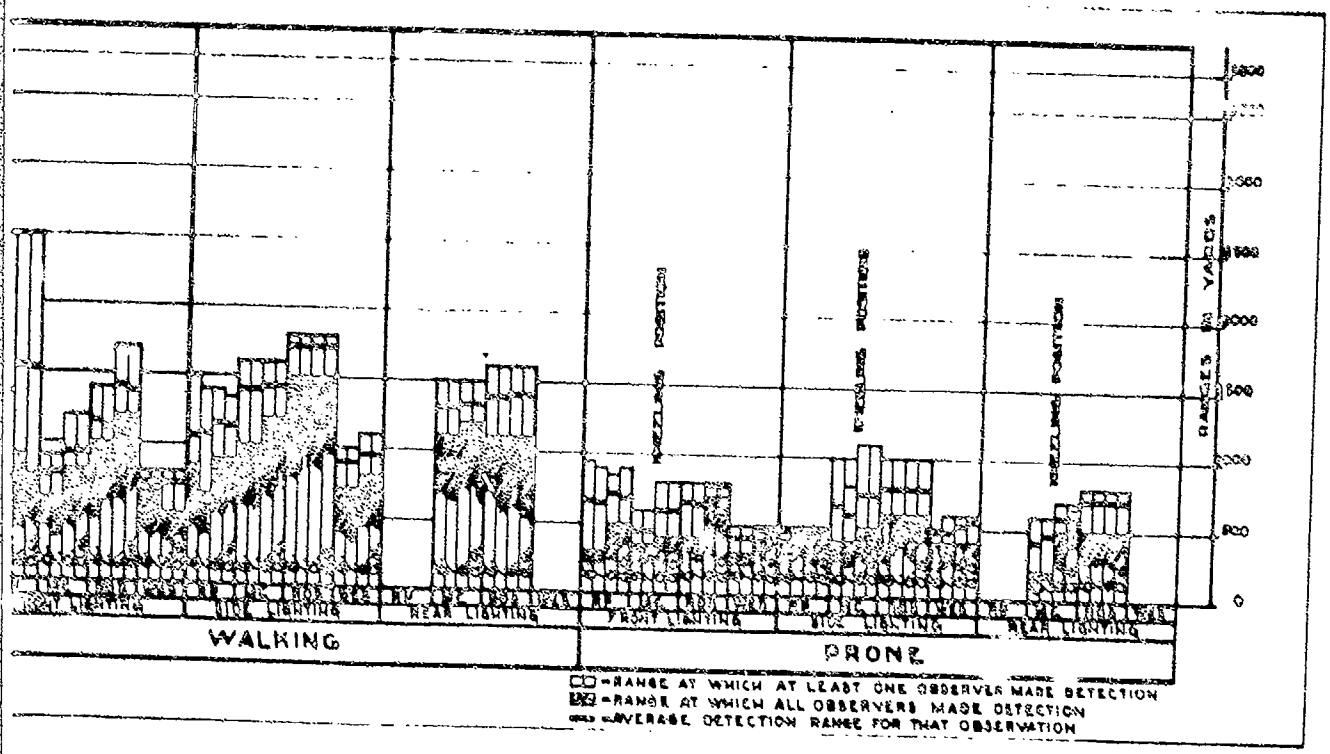


Fig. 42. Results of Test Series No. 2, models identified as men. All mod
matching colored load carrying equipment and helmet covers.



st Series No. 2, models detected as objects foreign to the
aring matching colored load carrying equipment and helmet covers.



Series No. 3, models identified as man. All models wearing
ying equipment and helmet covers.

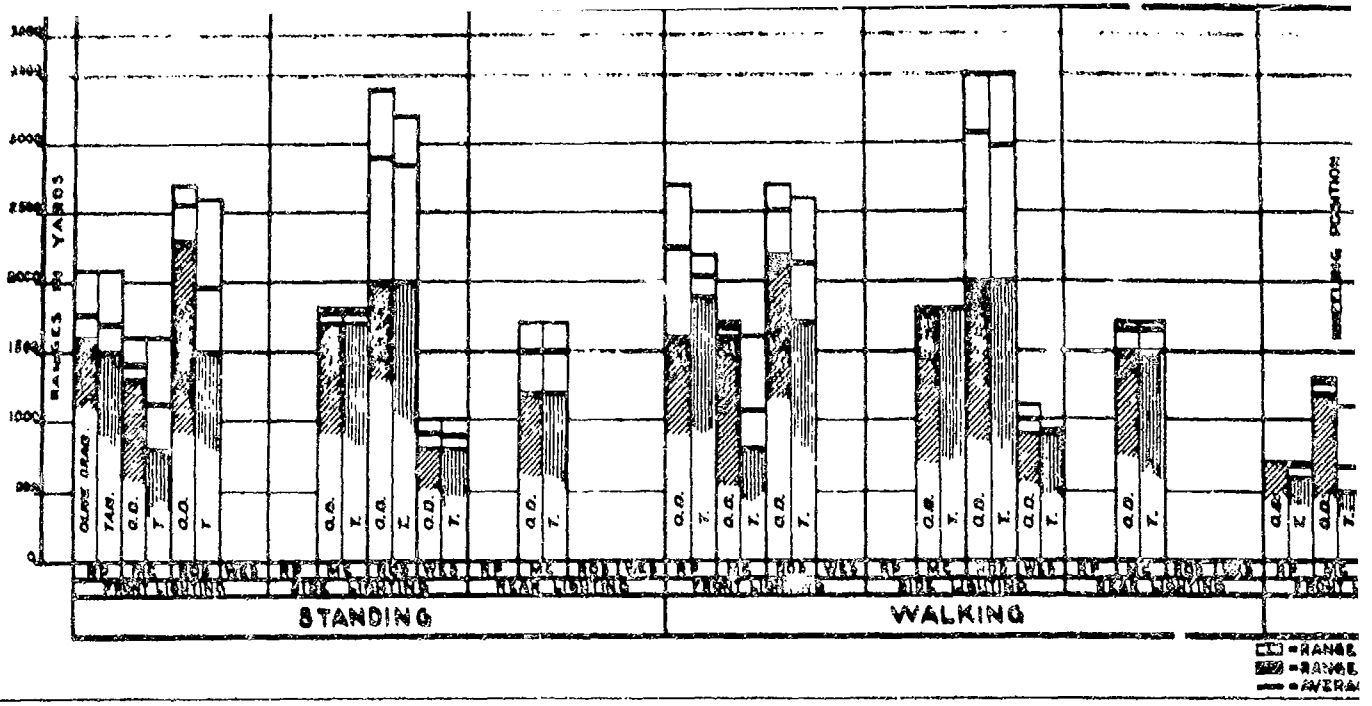


Fig. 43. Results of Test Series No. 3, models identified as objects. tan uniforms, two with olive-drab body armor and two with tan body ar

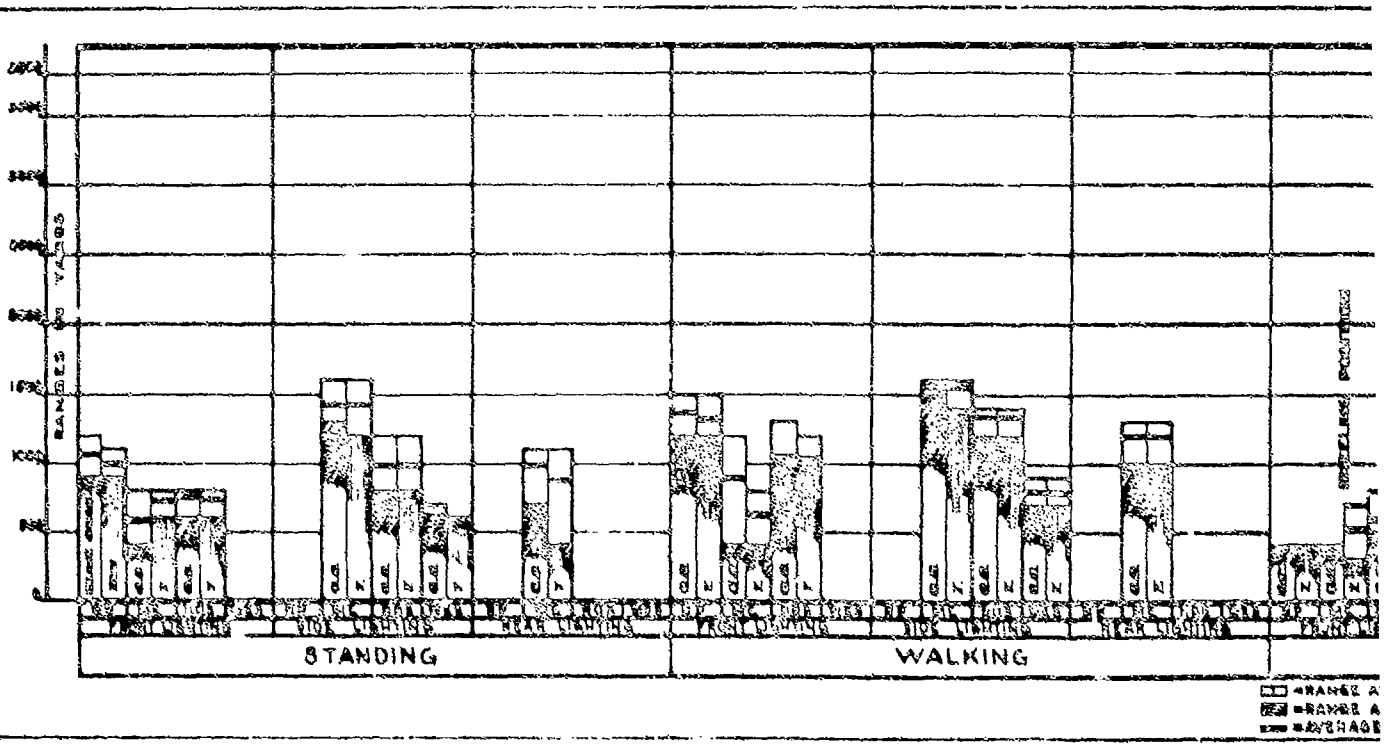
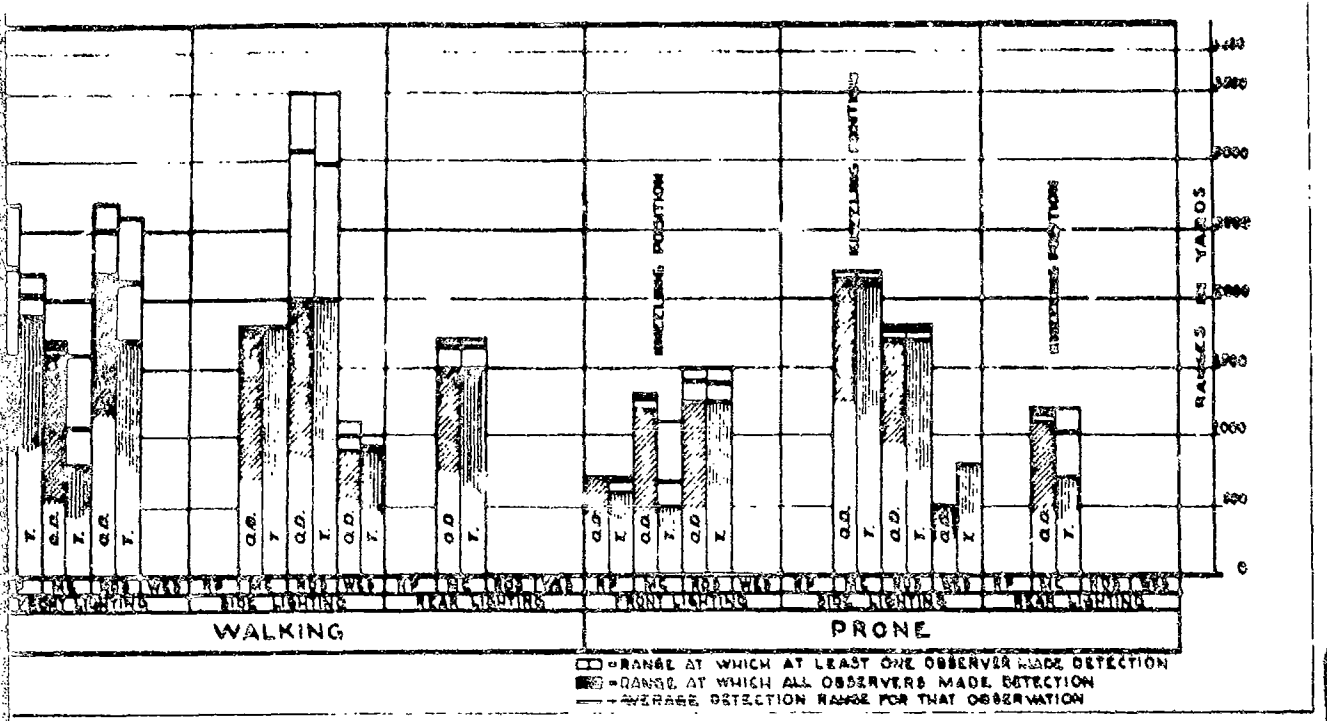
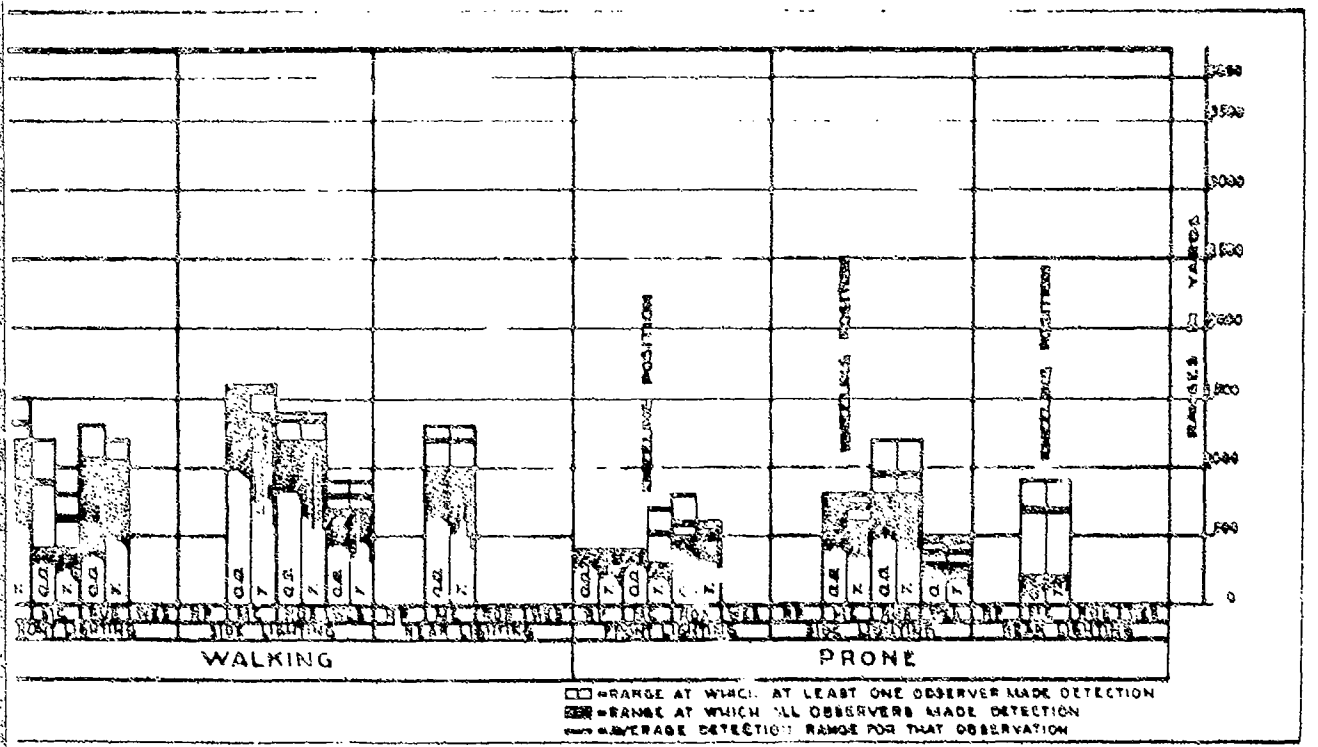


Fig. 44. Results of Test Series No. 3, models identified as men. All uniforms, two with olive-drab body armor and two with tan body armor.



...et Series No. 3, models identified as objects. All models in olive-drab body armor and two with tan body armor.



...et Series No. 3, models identified as men. All models in tan ...-drab body armor and two with tan body armor.

Comparison of 993 sample detection ranges from these sites show that the sites compare as shown in Table IV.

Table IV. Comparison Data of Desert Test Sites

Test Site	Average Detection Range	No. of Samples	Rating
Rosamond	2072.76	339	34.17
Rio Puerco	1740.27	214	28.67
Marble Canyon	1180.60	327	19.46
Westmorland	1072.97	113	17.68

Thus, it is evident that terrain does have considerable effect upon the ability to detect personnel, and the more complex the surrounding the more difficult the detection.

As with the other facets of this problem, it is not feasible to compare the effects of lighting on detection in a total sense because all tests at all sites were not run and a certain amount of interpolation is necessary. Even within this latitude, the results are contradictory. In Test Series No. 1 the relationship from best to worst is side light, front light, and rear light. Test Series No. 2, however, indicates side light still as best overall, but with front light and rear light alternating for worst. Test Series No. 3 shows front light superior to side light, but not enough rear light samples are available to give it a position. The best concealment range of the whole series was obtained under low angle front lighting conditions at Rosamond. Conversely, the farthest recorded range was obtained under the same general lighting conditions at the same site. This demonstrates that the effects of the lighting on the terrain as well as on the model must be considered when attempts are made to judge the optimum lighting condition for concealment. Test Series No. 1 and 2 indicated that side lighting would be best where mixed uniforms are involved, whereas Test Series No. 3 indicated that where a good color match is present, front lighting would provide the best concealment.

The effects of model position, or attitude as it has been termed herein, is almost obvious. The larger the target the more likely is detection. Movement is of extreme importance in this area of threshold. It was observed repeatedly that at distant ranges, i.e., beyond 1,000 yards, motion of models approaching head on was undetectable, but motion of models moving across the field was readily observed. In

circumstances where the models resembled clumps of brush or otherwise blended into the background pattern, the detection range for direct or approaching models was the same for standing or walking. For lateral movement of models under the same circumstances, the detection threshold of the walking models was much higher.

The extreme range recorded for detection of the models as objects is 3,800 yards, achieved with the green and olive-green ensembles at Rosamond Site. The visibility conditions were estimated at 30 miles with sunlight directly on the models from an elevation of 25° above the horizon, with an estimated sky-ground ratio of 1.2 to 1.5.

The minimum recorded range at which all observers detected all erect models as objects regardless of color ensemble, attitude, terrain, visibility, and lighting was 750 yards. Minimum detection of models in the prone position was 600 yards.

For personnel in uniform ensembles of colors darker than a perfect match to the terrain, the maximum unaided visual range where detection may be expected is approximately 4,000 yards. Theoretically under the conditions indicated above, a 10-square foot black target in a clear field would be detectable at approximately 5,000 yards. The fact that the olive-green uniform was not black but reflected some 9 percent of the light and the slight confusion of distant rocks and trees was sufficient to reduce the detection range to 3,800 yards. Since these elements will always be present to some degree, it is believed safe to assume that personnel are safe from detection by unaided visual observation beyond 4,000 yards in moderately broken or foliaged desert terrain. Conversely, even with excellent color match and with terrain, lighting, and visibility in one's favor, erect personnel can only get to within 600 feet of an enemy without being detected (except in a rainstorm or sandstorm). Utilization of terrain for approach and additional camouflage treatment through application of local garnish, face paint, rifle covers, and the like will obviously permit a much closer approach without detection.

(2) Identification as Men. A second factor of camouflage after detectability is recognition. If personnel are seen but not consciously registered as men or objects of military significance, they will go undetected. The second set of data was taken to determine at what point this recognition could be expected. The results are self-explanatory, and while the factors of light direction, terrain, and visibility again influenced the results, these have been examined in detail

above. In many situations of casual observation, these recognition thresholds become synonymous with detection.

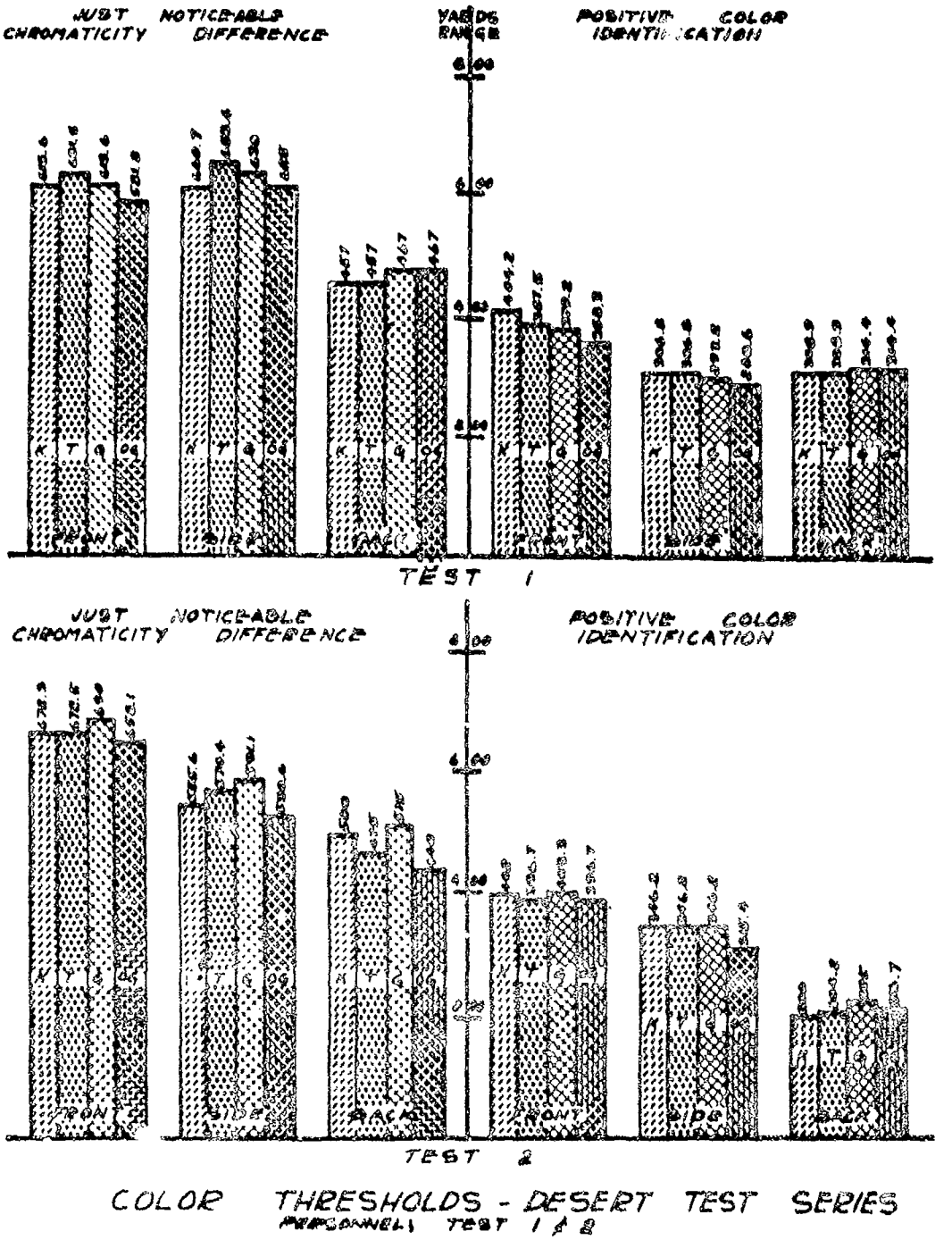
(3) The overall results of Block III with regard to color are shown in Fig. 45. Figure 22 gives the precise meanings of the terms "detected" and "identified." The word "color" here applies only to the chromatic aspects of color. Achromatic differences were often perceptible as far as the models could be seen. This was particularly true under front lighting conditions and often in excess of 1,000 yards when back lighted. While there is some indication as to color match with the terrain in the relationship of the light uniforms, it may be seen that the effects of lighting are much more pronounced. The results of two test series are given in this diagram.

(4) The results of Block IV, "Webbing Detected," are shown in Fig. 46. This diagram shows the results of all recorded range data pertaining to detection of load carrying equipment and rifles. The averages represented indicate the effect of lighting on the three test series.

(5) Answers to the questions on the rear of the test record form are presented in Table V. Since this side of the form was for the observers' subjective analyses of what was observed, the questions were only guides to permit rapid recording of reactions to the situation witnessed. Complete freedom, therefore, was given the individual in choosing the questions to be answered, this will explain the apparent lack of numerical continuity of the results. Table V covers only Test Series No. 1 and 2. The subjective results obtained from Test Series No. 3 were unanimously in favor of recommending that body armor be colored Tan or Khaki for desert use.

(6) Summary of Remarks. The following were noted by the observers during the tests and were recorded in the Remarks section of the test record forms:

(a) Mirage Effects. At Rosamond (Dry Lake) Site, heat mirage effects increased the detection ranges in many cases by doubling the target size and by apparently raising the targets off the ground. Scintillation of the targets further added apparent motion, thereby making them more eye catching. There was also noted a halo effect which seemed to envelop the targets at far ranges adding to their detectability. These effects in unison added many yards to the detection ranges at that site. Scrutiny of Fig. 36 will reveal the effects indicated above. The doubling of the target was a result of an inverted image directly beneath the target.



COLOR THRESHOLDS - DESERT TEST SERIES
PERSONNEL TEST 1 & 2

Fig. 45. Color thresholds, desert test series, personnel.

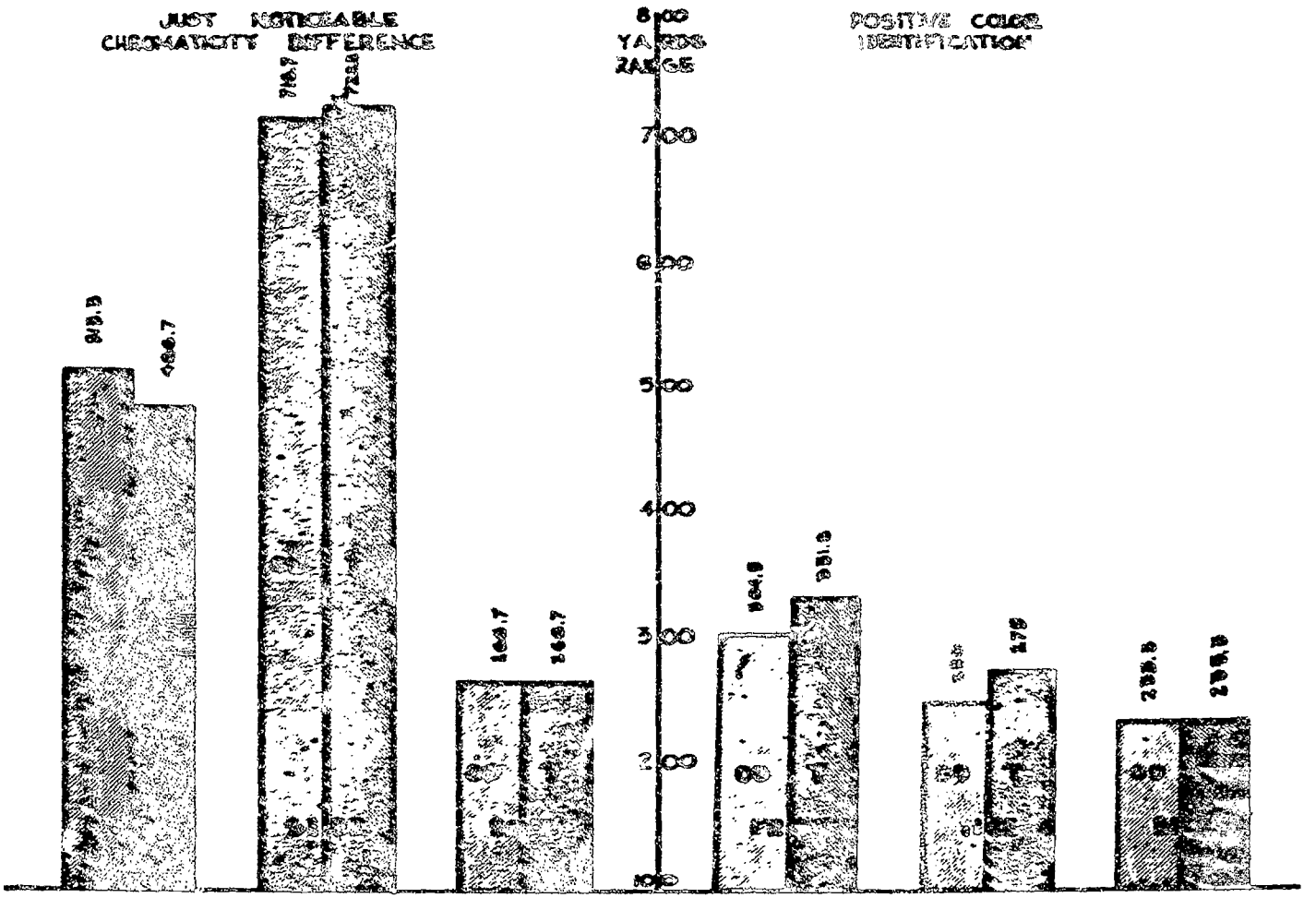


Fig. 46. Color thresholds, desert test series, packs and webbing.

Table V. Answers to Questions on Rear of Desert Test Form

QUESTION	TOTAL ANSWERS
1. What do you consider was the primary factor which permitted your initial detection of the models (movement, shadow, shine, etc.)	46 - Movement; 20 - Value; 15 - Shadow; 6 - Silhouette; 5 - Shine
2. As a rifleman, which of the items observed would you consider The best target, The poorest target, No difference?	Best Target 60 - Olive Green 107; 6 - Green 116 Poorest Target 30 Khaki #1; 28 Tan 112 No Difference - 11
3. As a result of this single observation I would select coloration for the following items as shown. (Colors OD-7; OG-107; Tan-112, Green-116, Khaki.) Item: Uniform, Pack, Body Armor, Belt & Suspenders, Rifle Cover, Helmet or Helmet Cover.	All Items Khaki 30; Tan 112 - 28; No Difference-11 Color Choice Khaki
4. I would prefer to have the webbing and pack the same color as the uniform.	Yes - 64; No - 0; No Difference - 4
5. As a result of this observation I would conclude that:	Yes / No
a. A helmet cover is desirable	45 / 0
b. The Marine Corps types are preferred	N/A
c. No helmet cover is necessary	2 / 11
d. There is no significant difference between the Marine and experimental types of helmet cover from a concealment viewpoint	N/A
e. The experimental type is preferred	N/A
f. The helmet without cover but properly colored provides sufficient camouflage	6 (Long Range) / 8
g. The body armor requires specific desert coloration	16 / 0
h. A rifle cover is desirable	9 / 5
i. A rifle cover is not necessary	16 / 7
j. The combat pack requires specific desert coloration	33 / 0
k. The suspenders & rifle belt require specific desert coloration	39 / 0
6. As a soldier in an attack on this OP under the conditions of this observation I prefer to be in a uniform of	30 Khaki; 28 Tan; 3 No Difference. 8 Tan 300 to 600 yds, Khaki under such range.

(b) Reappearance of Models. A phenomenon noted during the arctic studies was repeated occasionally during these tests. The model was detected as an object at a far range. Then, as the model progressively reduced the range between himself and the observer, he became for a time extremely difficult to see, only to again appear clearly at a closer range. This was noted with the Tan color more than with the Khaki.

(c) Effects of Perspiration. Excessive perspiration caused a darkening of the uniform sufficient to increase its conspicuousness. No comparative data was obtained, however. The effect was more noticeable on the light-colored items since the dark-colored uniforms were in the main already conspicuous.

(d) Helmet Camouflage. The burlap helmet covers increased the camouflage of the uniforms noticeably up to 300 or 400 yards. Beyond that range, there was a difference of opinion as to the effectiveness. Some observers felt that properly colored helmets provided results equal to the helmet cover; others indicated that the texture surface provided by the burlap increased its effectiveness over color alone.

(e) Conspicuousness of Rifles at Port Arms. The carrying of the rifle at port arms increased the shadow area on the front of the uniform. When added to the dark rifle, this shadow area was sufficient to darken the uniform considerably, permitting its earlier detection.

(f) Detection of Forward Motion. While the motion of the models normal to the line of sight was detectable at the greatest ranges, motion in the direction of the line of sight was undetectable until the models were sufficiently close to permit the scintillating movements of the arms and legs to be seen. This range was usually between 800 and 1,000 yards.

(g) Luster of Tan 112 Uniform. There was a rosy colored luster to the Tan 112 uniform used in the tests which was not particularly noted beyond 500 yards but which became increasingly conspicuous under that range. This resulted in frequent remarks to the effect that Tan was the preferred color beyond 300 yards, with Khaki preferred under that range.

(h) Head-On Versus Lateral Prone Position. It was noted especially at Rosamond Site that the models were

more conspicuous in the head-on prone position than erect. This was caused by the shadow cast on the chest and neck which appeared as a black bull's-eye. The lateral prone position did not have this feature and was, therefore, much less conspicuous (Fig. 35).

(7) Conspicuousness of Items. The diagrams and objective data obtained from these tests show clearly the degree that color may be expected to contribute to the complete visual concealment of personnel. The relative conspicuousness of the ensembles observed is not shown and is not a factor therein. Equally important and perhaps even more important militarily are the evaluations of the observer's ability to obtain a clearly defined target if the observer were a rifleman. In front and side lighting and to a lesser extent in back lighting conditions, the relative conspicuousness between the light and dark uniforms was extreme. The light uniforms could be seen but were indistinct and fugitive; the dark uniforms were bull's-eyes in a light surrounding and were extremely eye catching (Figs. 30 through 37). When an arbitrary scale of 1,000 was used as representing the most conspicuous ensemble tested, the remarks on the test record forms and personal interviews with each of the observers indicated that the order of conspicuousness of the ensembles was approximately as follows:

Uniform Ensemble Color	Relative Conspicuity
Olive Green 107	1,000
Green 11[illegible]	900
Khaki No. 1 (beyond 300 yards)	300
Khaki No. 1 (under 300 yards)	250
Tan 112 (beyond 300 yards)	250
Tan 112 (under 300 yards)	300

(8) Night Test. The average results from the night test held at Marble Canyon are shown in Table VI. The test was held only for comparative purposes, since the 1951 desert test series had concluded that the optimum nighttime coloration was the same as that for daylight in this open terrain. Observations repeated at Westmorland Site confirmed the relationships noted at Marble Canyon. For comparative purposes, observations were made at Westmorland using beamed artificial light from both single and double truck headlights to determine the effects this type of lighting would have on coloration (Fig. 38). In this situation, the optimum coloration desired reversed and the dark uniforms were found to be superior.

Table VI. Marble Canyon Night Test Results,
Test Series No. 2 Uniform Ensembles

Uniform Ensemble	Detected as Objects		Identified as Men		
	Standing	Walking	Kneeling	Standing	Walking
Olive Green 107	31	33	16	12	14
Green 116	32	33	16	12	13
Khaki No. 1	21	26	11	10	14
Tan 112	24	26	13	12	15

NOTES: Clear night, no moon.
Readings in yards.

(9) Lighting Effects Versus Detectability of Personnel. The results of the series of photographs taken at Rosamond Site showing the effects of lighting direction in connection with the detection of personnel are presented in Fig. 47. This series of photographs amply illustrates the limitations of coloration in the concealment problem.

(10) Correlation of Combat Uniform Coloration With Other Military Equipment. Figure 48 illustrates the danger inherent in any attempt to establish a general color specification for all military items. The light tent was colored with the same colorant used on the load carrying equipment worn by the model during the threshold tests. However, the large, flat, relatively smooth surface unaltered by small shadow areas inherent on a uniform results in an obvious mismatch to the terrain. These photographs were selected because they were taken in overcast lighting which minimizes surface glare.

b. Hot-Wet Terrain. Because of the close nature of the Panama terrain, the studies there did not adapt themselves to the test approach followed for the desert and arctic areas. The results are almost wholly subjective and not as impressive in presentation, but are none the less important. The value component of color was found to predominate over chromaticity in the hot-dry areas, whereas the chromaticity was found to be of major importance in the hot-wet areas because of the close ranges and form-destroying shadows found in foliaged areas. In Fig. 49 and Fig. 50, the general results of the observations are presented. The numerical rating of the uniforms is an arbitrary scale established solely to convey the order of camouflage effectiveness observed. It is obvious from those figures that the flock-patterned uniform was superior in effectiveness to all the others and that the Green RPS-1 color was superior

as far as the solid shades were concerned. The other patterns and colors of items observed were either poor color or poor pattern blend to the local scene and are, therefore, not considered. The advantage of special coloration and pattern varied with the density of the undergrowth, becoming less advantageous as the density increased. In typical second growth jungle, the tan colors could be seen on moving personnel approximately one-third farther than the greens. Figures 51 through 59 are presented to graphically illustrate the types of terrain in which observations are made and to show within the capabilities of the photography the comparisons observed. The following are specific results of the various studies conducted:

(1) The increased camouflage effectiveness of green load carrying equipment over the standard olive-drab coloration was insignificant.

(2) If worn outside the jacket, body armor in standard olive-drab coloration nullified to a major extent the advantage gained by the green uniforms.

(3) Helmet covers added significantly to the effective camouflage of the individual, especially in open forest areas.

(4) The green colored burlap helmet cover was significantly superior in camouflage effectiveness to the cloth types, including the Marine Corps standard.

(5) Green 116 was too blue and too intense (high in chroma) for a good terrain match. Likewise, the Olive Green 107 was generally a mismatch because it was too grey or too dark. The Green RPS-1 color, while the best solid shade tested, was somewhat low in purity.

(6) The limited tests conducted indicated an optimum infrared reflectance of 25 percent for uniforms for concealment against the sniperscope at night.

(7) Uniforms possessing infrared patterns of small area and medium contrast design improved their camouflage effectiveness at night against sniperscope observation.

(8) The spray can field colorant successfully toned down and patterned a khaki colored uniform but made the uniform stiff and clogged the pores of the fabric to an extent sufficient to cause rejection of the colorant as a field expedient coloration method.

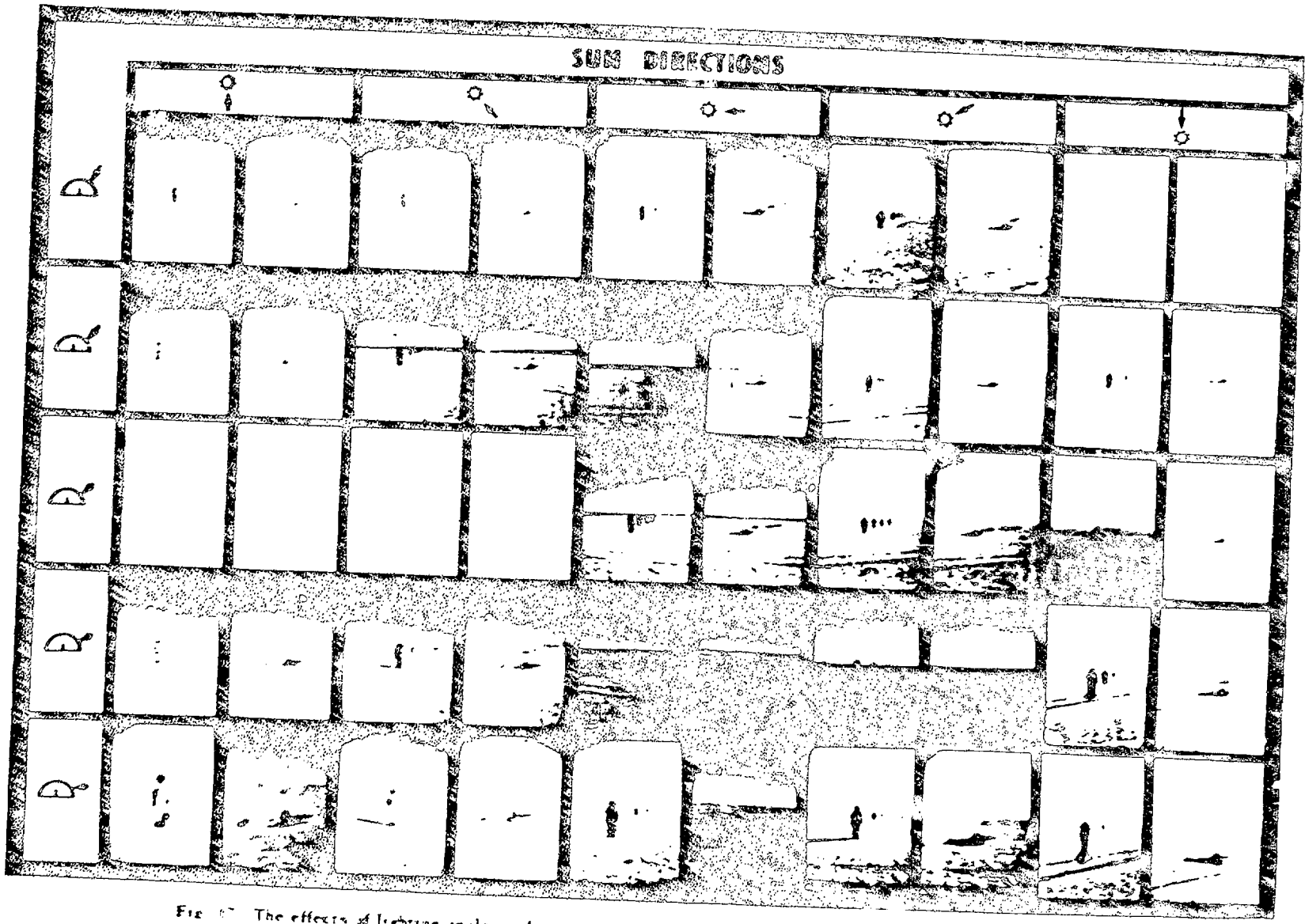


Fig. 1. The effects of lighting angle on [illegible]

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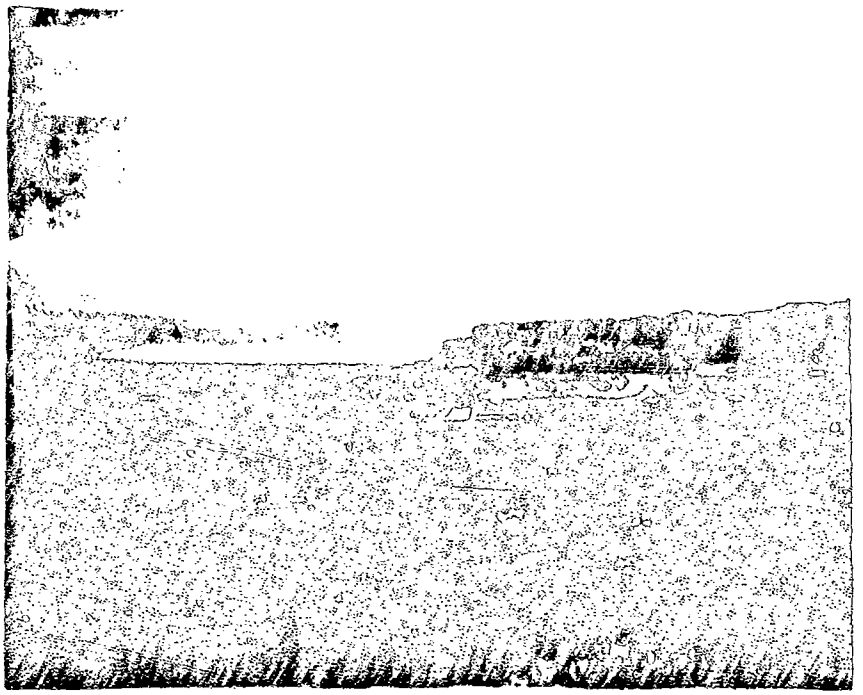
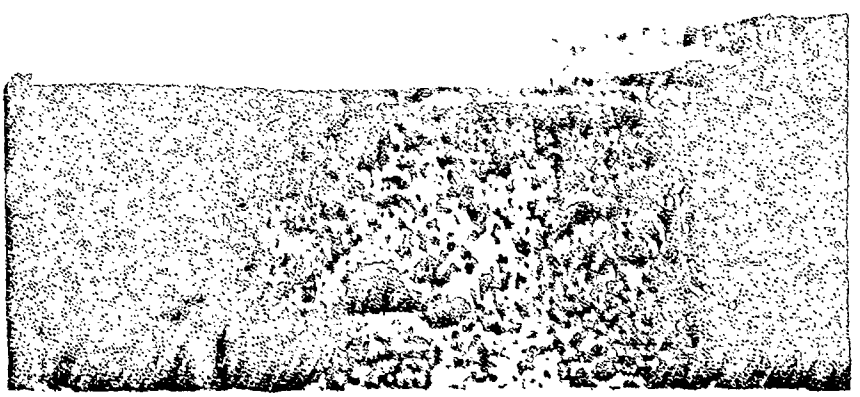
Fig. 48. Examples of attempts to base color requirements for other items of equipment upon that determined to be optimum for combat uniforms without first considering the item's other properties. Top: Two-man tents at 50 yards. Tent on left in Tan 112 color. Tent on right toned down to value match with local terrain. Bottom: Same items as above, at 500 yards.





TERRAIN TYPE		KHAKI	TAN	GREEN 116	GREEN RPS-1	O.G. 107	FLOCK PATTERN
VIRGIN FOREST		5TH. 15	5TH. 15	4TH 90	2ND. 98	3RD. 95	1ST. 100
SECOND GROWTH FOREST		5TH. 20	5TH. 20	4TH. 84	2ND. 90	3RD. 85	1ST. 100
TRAIL	OPEN	5TH. 10	5TH. 10	3RD. 80	2ND. 95	4TH. 78	1ST. 100
	FOREST	5TH. 12	5TH. 12	4TH. 78	2ND. 98	3RD. 80	1ST. 100
TALL GRASS & BRUSH (MIGRATORY CULTIVATION)		5TH. 25	5TH. 25	4TH. 84	2ND. 95	3RD. 85	1ST. 100
DRY CANE & GRASS		1ST. 100	2ND. 90	4TH 20	4TH. 20	4TH. 20	3RD. 80
SHORT GRASS (GREEN)	FRONT LIGHT	5TH. 10	5TH. 10	3RD. 90	1ST. 100	4TH. 85	2ND. 95
	SIDE LIGHT	5TH. 15	5TH 15	3RD. 90	1ST. 100	4TH. 85	2ND. 95
	BACK LIGHT	5TH. 80	5TH. 80	3RD. 95	1ST. 100	4TH 99	2ND. 98
MANGROVE SWAMP (ROOTS)		5TH. 35	4TH 40	6TH. 30	2ND. 90	1ST. 100	3RD. 80
LOCAL BEACH SAND		2ND. 85	1ST. 100	3RD. 5	3RD. 5	3RD. 5	3RD. 5

THE NUMERICAL SCALE IS ARBITRARY WITH 100 REPRESENTING THE BEST UNIFORM OBSERVED IN THAT AREA NOT NECESSARELY A PERFECT BLEND.

Fig. 49. General results of hot-wet observation in Panama Canal Zone.

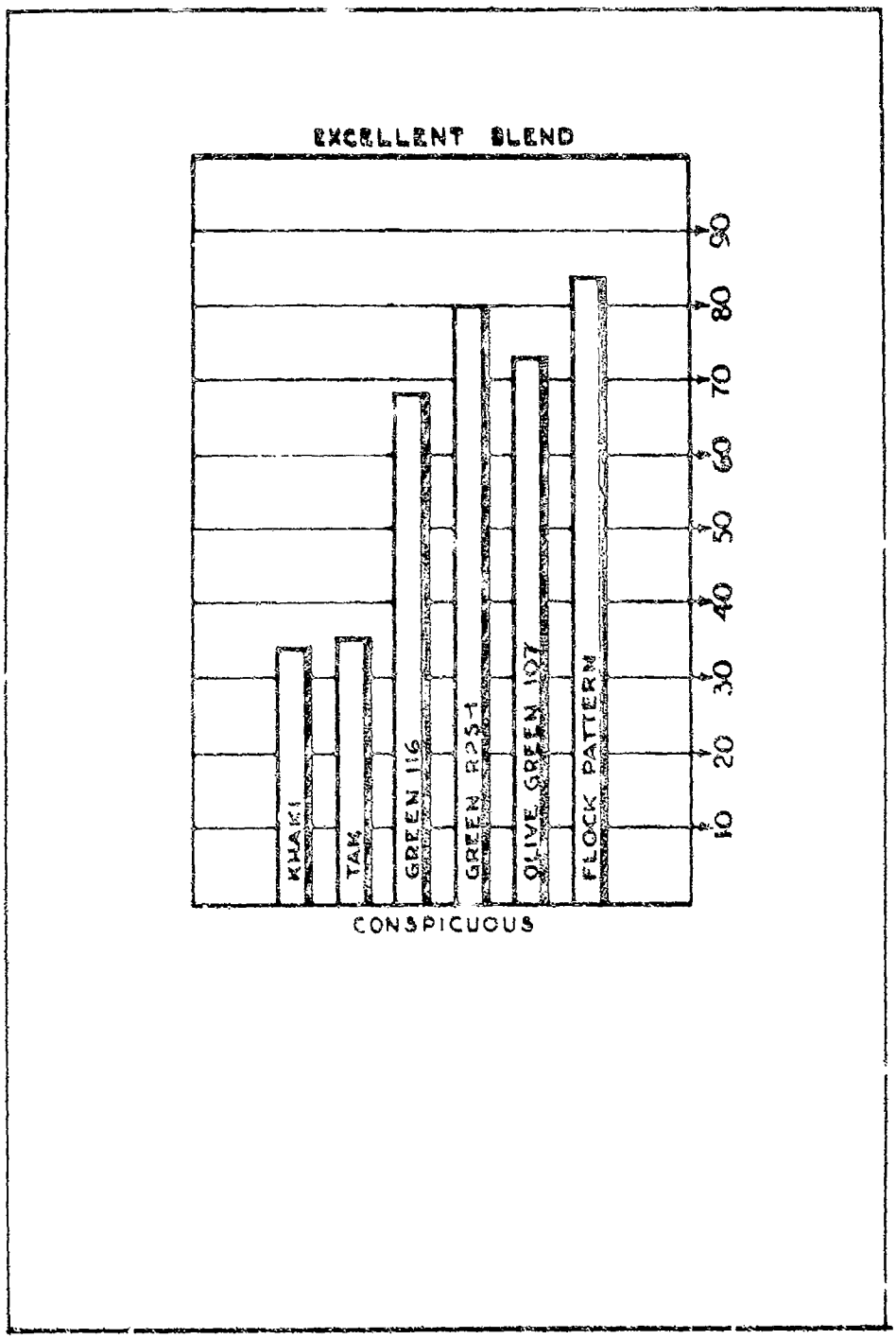


Fig. 50. Relative camouflage effectiveness of uniforms tested in hot-wet terrains in Panama Canal Zone.

05957

05959

Fig. 51. Virgin forest area, Fort Sherman, Canal Zone. Top: Models (left to right) are Green 116, flock pattern, and Tan 112. Bottom: Models (left to right) are top row Tan 112, Green 116, and flock pattern; bottom row Green RPS-1, Olive Green 107, and Khaki No. 1. All models are in view from waist up.

G5961

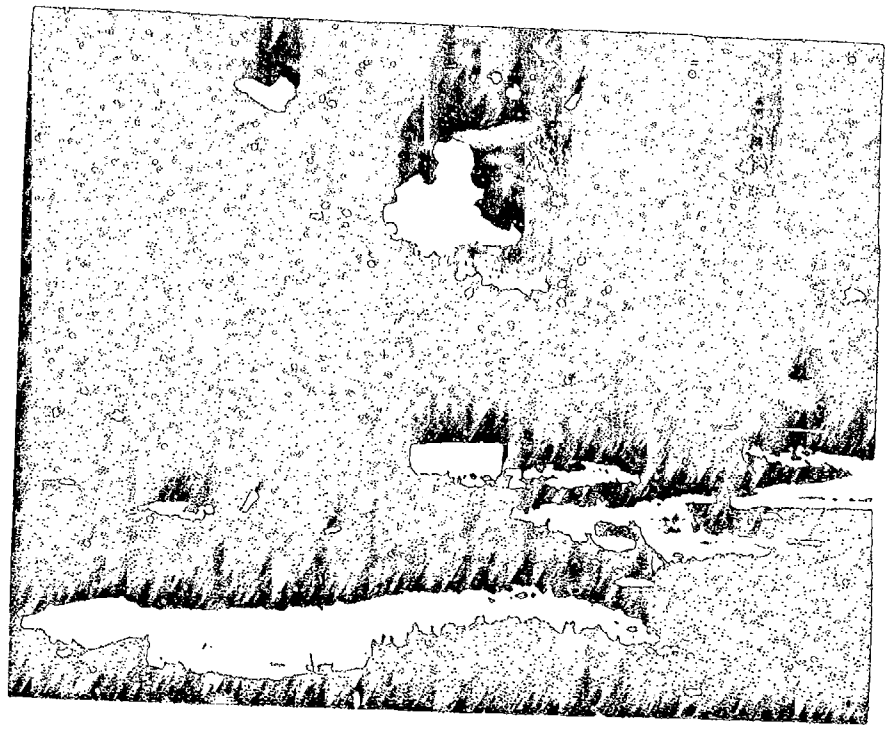
G5960

Fig. 52. Second growth jungle. Models (left to right) are Khaki No. 1, flock pattern, Green 116, Tan 112, Green RPS-1, and Olive Green 107. Load carrying equipment same color as uniforms. Top: Front view of models. Bottom: Rear view of models.

05964

05962

Fig. 53. Tall grass areas, Fort Sherman, Canal Zone. Top: Models (left to right) are flock pattern, Khaki No. 1, Tan 112, Green RPS-1, Green 116, and Olive Green 107. Bottom: Models (left to right) are Olive Green 107, Green 116, experimental pattern, Tan 112, experimental pattern, and flock pattern.



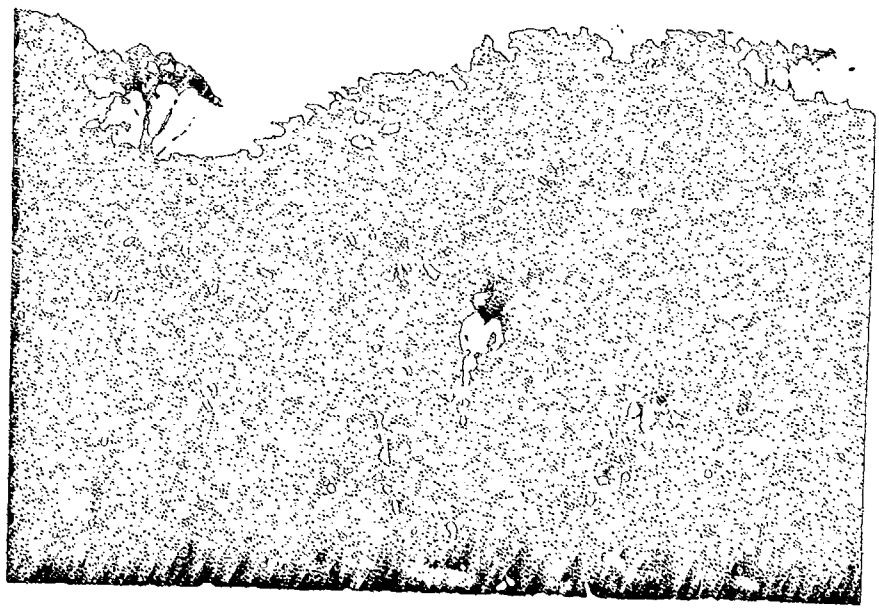
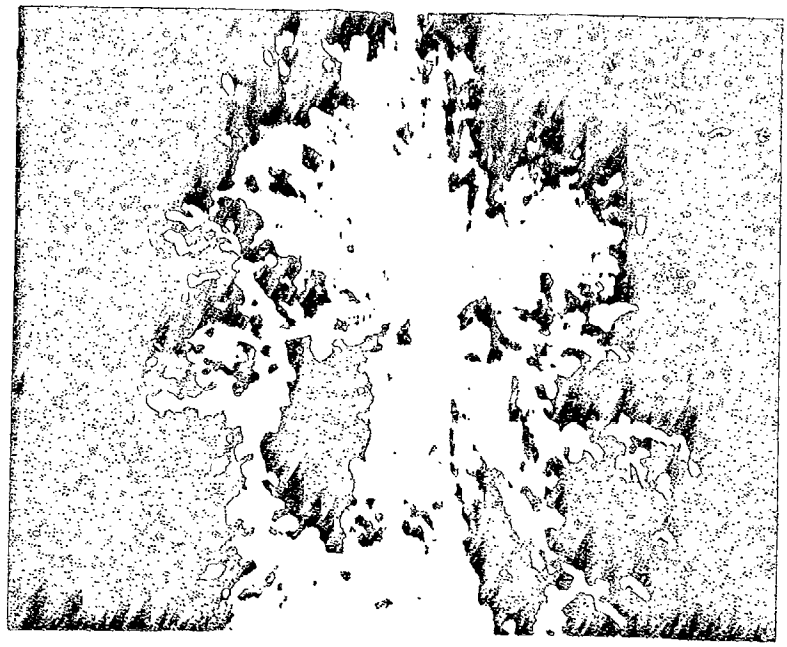
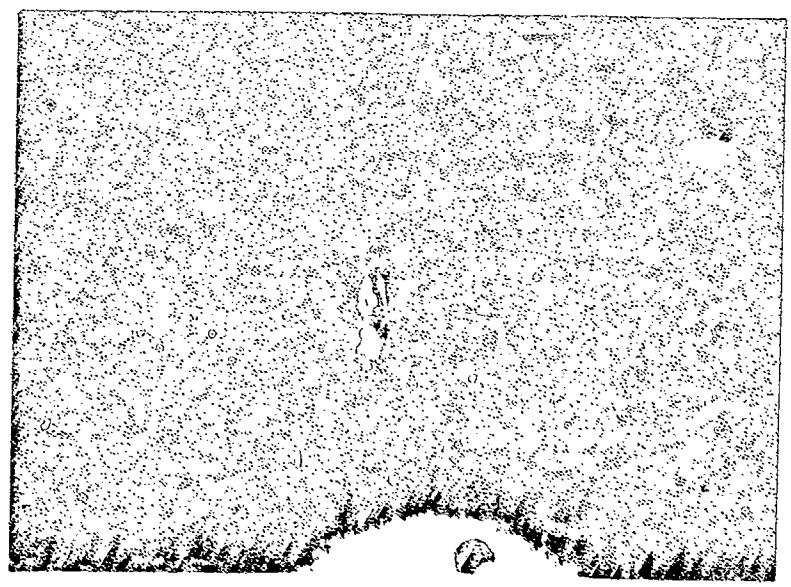


Fig. [illegible]. Short grass area, Fort Colick, Canal Zone. Models (left to right) are flock pattern, Khaki No. 1, Green HPS-1, Tan 112, Green 116, and Olive Green 107. All models are wearing olive-drab load carrying equipment. Side lighting. M11976



A7518



A7533

Fig. 55. Snipercope observation. Top: Daylight. Models (left to right) experimental summer temperate pattern and Grey No. 210. Bottom: Night. Models (left to right) Tan 112, Khaki No. 1, Green RPS-1, and Green 116.

(9) Camouflage face paint used on the face and hands greatly reduced the conspicuousness of these noticeable body parts. These parts untreated were often the only means of locating otherwise well blended personnel.

III. DISCUSSION

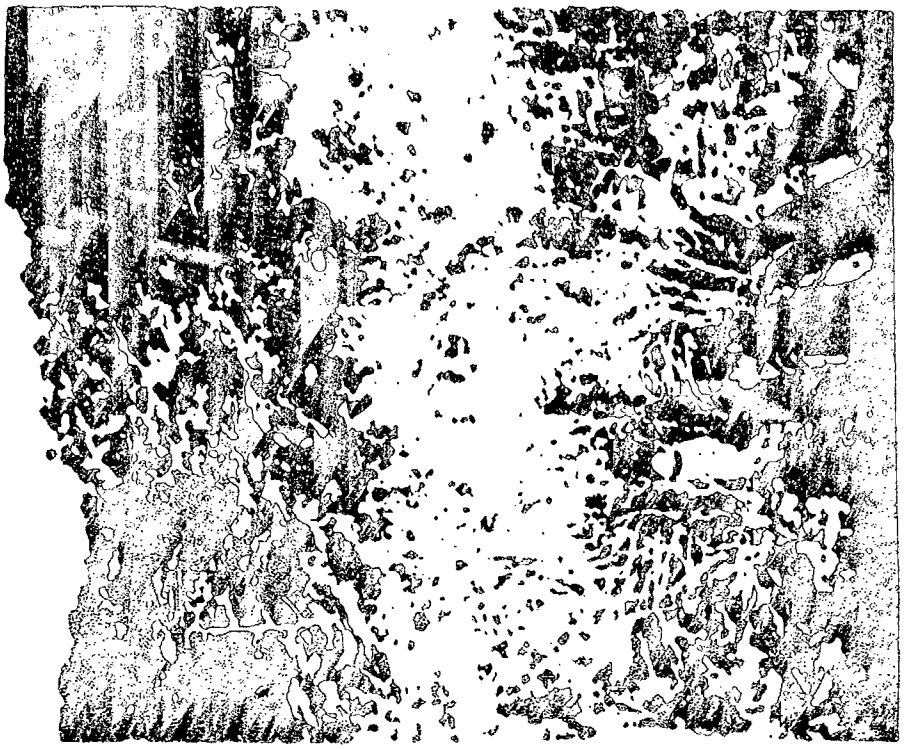
10. Correlation with Program. Some readers may question the justification of such an extensive program. An extensive program had been accomplished in 1951 with regard to desert coloration, and a color for the tropical areas had been chosen as a result of tests in live green surroundings at Fort Belvoir, Virginia. These studies had been based upon the assumption that there was a definite requirement for two environmental uniforms to meet these conditions and upon the general feeling that two colors were required to provide camouflage for so diversified a set of conditions. The unexpected AFF Board No. 3 position that only one hot-weather combat uniform was necessary threw the burden of proof upon the Corps of Engineers and the Quartermaster Corps to show that the military necessity or advantage of two uniforms in two colors outweighed the logistics and supposed procurement problems. Little factual data was available to show the necessity for or advantage gained from coloration match to the terrain. Much had been done to determine the optimum coloration within the broad types of terrains on a worldwide basis, but this position of Board No. 3 (while not supported by AFF Headquarters) challenged the assumptions upon which the other work had been based. As can be determined from the Memorandum from G4 to QMG and CE (Appendix A, Exhibit A, Inclosure 1), no decision was reached at the meeting of 15 May 1953. The studies, tests, and program covered by this report were, therefore, directed toward the determination of the military advantage to be expected from optimum coloration even though this end would require a subjective analysis. This task, it is believed, has been accomplished, and a substantial case has been made showing the advantages of proper coloration. Further, the situation precipitated by this controversy permitted a continuation of the color studies and a chance to check the previous findings. Two important considerations concerning this work will be presented in separate reports. The first consideration involves the correlation of the test sites to worldwide areas of similar nature which make the results valid. While the interim report on the winter arctic[3] covered the correlation of snow-covered terrains, continued investigation of this aspect on deserts, jungles, and temperate areas had produced data of considerable proportions. Further, taken in toto, such studies have importance in camouflage beyond the scope of combat uniforms. Therefore, a separate publication will be issued

3. ENDL Report 133, Winter Arctic Camouflage Investigation, by Q. C. DeAngelis, 8 December 1953.

05943

Fig. 56. Mangrove areas, Fort Sherman, Canal Zone. Top: Air view of mangrove area. Note the density of overhead cover. Bottom: Models among the roots of the mangrove (left to right) Tan 112, Olive Green 107, Khaki No. 1, Green 116, and Green RPS-1.

Fig. 57. Left: Models in edge of clearing (left to right) experimental summer temperate pattern, Green 116 patterned with spray gun, and flock pattern. Right: Models in Kuin grass (left to right) Green RPS-1, Khaki No. 1, Tan 112, and flock pattern.



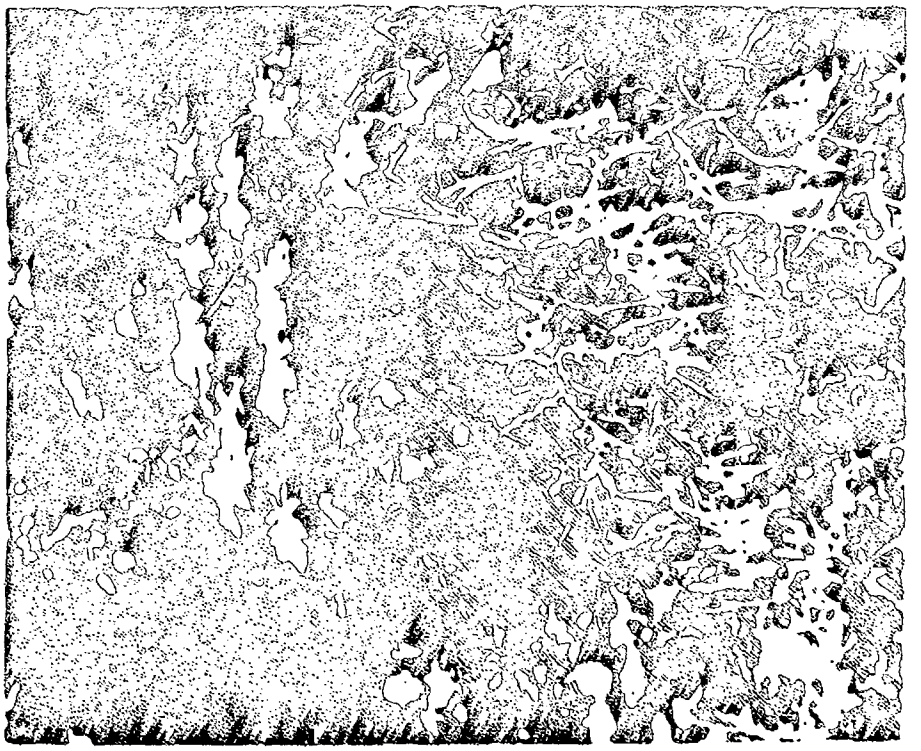
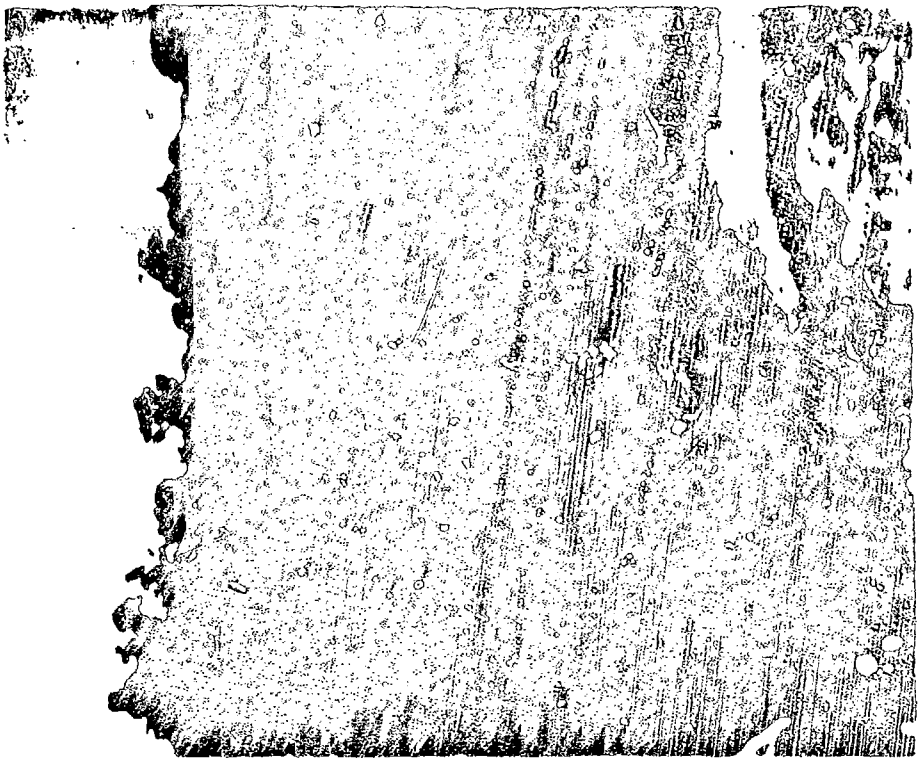
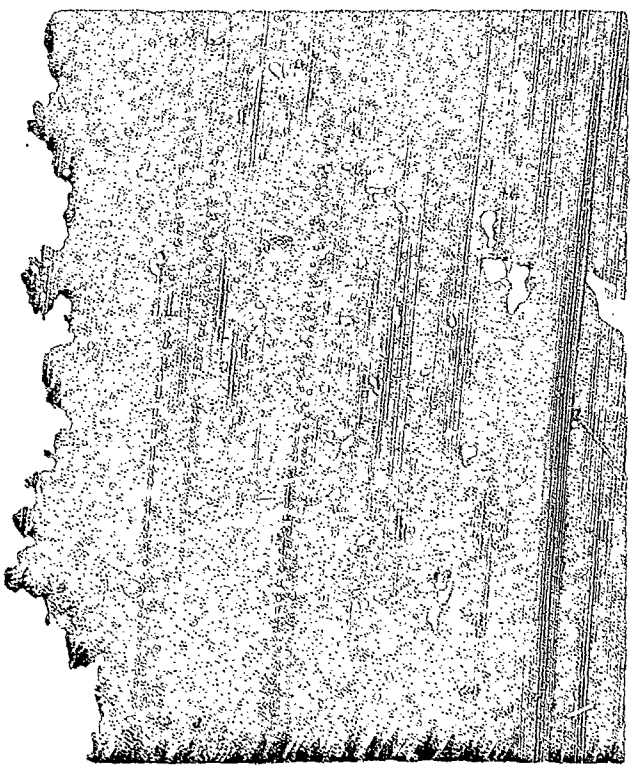


Fig. 58. Open trail, Battery Pratt. Left: Models (front to rear) Olive Green 107, Green 116, Green KPS-1, Tan 112, Khaki No. 1, and flock pattern. Side lighting. Colors match load carrying equipment (Test Series No. 2). Right: Models (front to rear) Green 116, without armor; Green 116, with olive-drab body armor; Green KPS-1, without armor; Green 116, with body armor; flock pattern, without armor (Test Series No. 2).





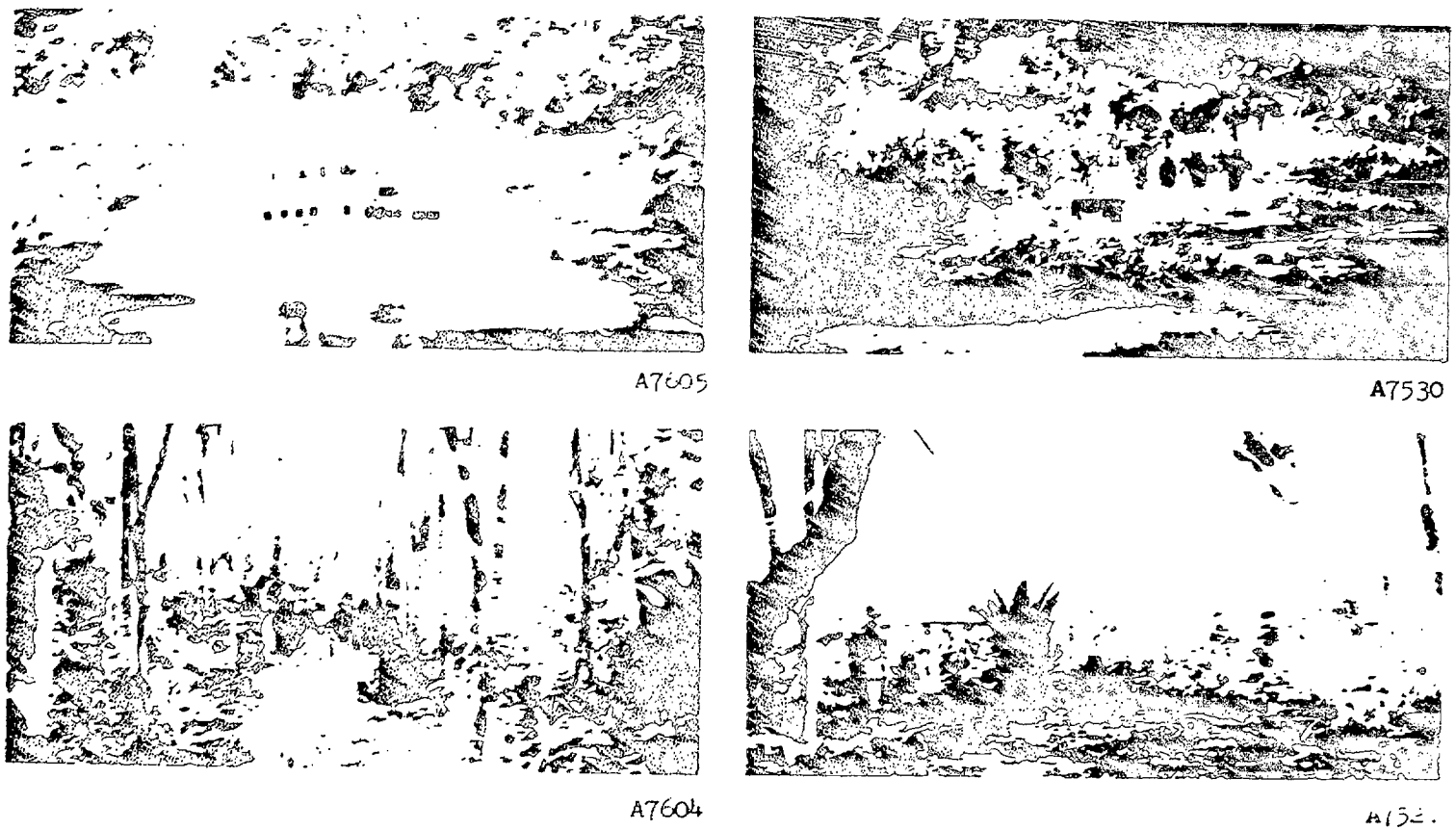


Fig. 59. Photographs taken with infrared film and Wratten 89 filter. Upper left: Models standing to rear of cloth panels (left to right) Tan 112, Khaki No. 1, Green 116, Green RPS-1, flock pattern, and Olive Green 107. Upper right: Models (left to right) flock pattern, Khaki No. , Tan 112, Green RPS-1, Green 116, and Olive Green 107. Lower left: Models (left to right) Khaki No. 1, flock pattern, Green 116, Tan 112, Green RPS-1, and Olive Green 107. Lower right: Models (left to right) Green 116, Tan 112, Olive Green 107, flock pattern, Green RPS-1, and Khaki No. 1.

covering that aspect alone. Secondly, the relationship of the field observations with the predictions of theoretical analysis has been omitted. It may not be generally known that considerable progress has been made since World War II in the mathematical treatment of visual problems. Much is yet to be desired in order to adequately predict with assured results what will or will not be detectable under given military conditions, but the tolerance limits are being continuously narrowed. It is planned that a full treatment of the theory shall be presented in the final project report, at which time the results from this and the other studies shall be related to the theoretical analysis.

It is planned to combine the motion pictures made during this work with those of the other phases. One report film will be prepared and published as a supplement to the final report.

11. Examination of Test Methods. The tests used in the desert portion are of the threshold type and are an adaptation of psychological studies in the visual field which have been in existence for some time. In analysis of the charts, care must be exercised in attempting to draw conclusions other than those specifically indicated. The observations were made to obtain an idea of the total magnitude of the problem, the effect which color can generally be expected to exercise on detection, the relationships between the various colors used, and an indication of the magnitude of the effects which lighting, terrain type, troop attitude, etc., have on detection and, therefore, concealment. Further, it must be remembered that while there were a great many observations, for each characteristic the statistical base is small, the observers few, and the conditions uncontrolled except in a broad way.

Another facet of the tests was the attempt to obtain the color aspects of camouflage on an objective basis where factual data uninfluenced by personal beliefs, insofar as possible, may be used to support the conclusions. Considerable difficulty has stemmed from the idea that camouflage is an art, and tests in the concealment of individuals have been reported on a subjective basis of interpretation of what was seen and are, therefore, open to considerable argument. Objective analysis is as yet unattainable but at least some progress has been made in that direction. In the case of the jungle observations, the situation still is one of a subjective analysis of the advantages to be gained. The detection ranges are so short as to be meaningless, and detection or concealment often depended on some insignificant movement or detail unrelated to the uniform. This must be analyzed in terms of the situation presented by such closed areas and a careful consideration of how much of the fighting could be expected to take place in confined areas as compared to the more open areas where color begins to influence the concealme. . To that end, local jungle warfare experts were

interviewed and their remarks considered in arriving at conclusions. The Panama tests may be said to be objective only insofar as the findings and conclusions of the observers were unanimous in all respects. The reasons for and the relationship of the test methods used to the other phases of this project are an outgrowth of the development of test methods in the early stages of the investigation and have more meaning when other reports under this project are read.

12. Analysis of Test Results Graphical charts were used for the presentation of the results of these observations as a means of presenting a pictorial relationship of the results in terms of the effects of the elements of the situation on detection. Even this method has limitations. However, color in the desert has more influence upon the detectability under side lighting conditions than any other; this finding is in agreement with the winter arctic studies. Otherwise, the results were approximately as contemplated. Of special interest to instructors in camouflage techniques is the effect that relative positions of the model, observer, and light source have on the enemy's ability to detect personnel in the desert. Furthermore, the carrying of rifles at port arms has enough shadow effect to materially increase the probability of the man's detection at longer ranges. Another important and interesting aspect was the inability of the observers to detect motion of the models approaching directly toward the observer. The charts present an indication of this when the standing versus walking sections are compared

Two final comments are concerned with the degree in which the charts may be misinterpreted. The first is that foreknowledge limited the possibilities before the observers and, therefore, must affect the results. The observers knew that men were to be involved and that only two or three series were to be run; therefore, the possibilities of error was limited to those. Secondly, because of the method of observation, the detection of one model gave location to the others and thereby contributed greatly to their detection. The effects of these factors can be interpreted in two ways; the first is that the differences shown by the charts are less than would be found in a random observation of single models; and the second is that rapid detection of a larger group of troops may be expected to be dependent on the detection of the first individual. This detection does not relate in any way to the conspicuousness of the individuals. If Figs. 30 and 33 are compared, it may be seen that the placing of all models in good color blend has reduced the detection threshold considerably over the same color in tests where the dark uniforms served as a reference point.

IV. CONCLUSIONS

13. Conclusions. It is concluded that:

a. There is a significant military advantage gained from the use of tan coloration in hot-dry terrains (deserts) and from the use of green coloration in hot-wet (tropical) areas.

b. Light tan coloration (as exemplified by the Khaki No. 1 and Tan 112 colors used in these tests) provides significantly superior camouflage over green and olive-drab colors for combat uniforms to be used in desert (hot-dry) and semidesert terrains.

c. Medium dark yellow-green coloration (as exemplified by the experimental summer temperate color QM Code RPS-1, Olive Green 107, and Green 116) provides significantly superior camouflage over the tan and khaki colors for combat uniforms to be used in tropical (hot-wet) terrains.

d. The experimental nylon flock-patterned uniform was superior in camouflage effectiveness to all others with which it was compared in the Panama Canal Zone.

e. The superior camouflage effectiveness of the Green, QM Code RPS-1, over the other solid shade colors with which it was compared was sufficient to warrant its adoption as coloration for hot-wet combat uniform ensembles.

f. If worn outside the jacket, body armor requires special colorations matching those recommended for the uniform for significant camouflage effectiveness to be retained.

g. Light tan load carrying equipment and small auxiliary equipment carried by the individual, while not conspicuous except at close ranges (under 400 yards), provide additional camouflage worthy of consideration for use with hot-dry uniform ensembles.

h. There is insufficient additional camouflage gained to warrant special coloration other than Olive Green 107 for load carrying equipment and other small auxiliary equipment carried by average troops in tropical (hot-wet) terrains.

i. The burlap helmet cover in colors to match the respective uniform with which worn is significantly superior to other types with which it was compared.

j. The Tan 112 coloration is superior to Khaki No. 1 in hot-dry terrain at ranges over 300 yards; the opposite is true under 300 yards, but the advantage is slight in either case.

k. Although the spray can colorant is capable of performing its camouflage mission adequately, it is unsuitable for field use in its current form.

l. The use of face paint should be vigorously taught in all units being trained for duty in heavily foliaged terrains.

APPENDICES

APPENDIX A Exhibit 1

AUTHORITY

WAR DEPARTMENT
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON 25, D. C.

ENGNB 3 June 1948

SUBJECT: Patterns, Camouflage Clothing, Project No. 8-31-02-004, Approval of Military Characteristics and Authorization of Project.

TO: The Commanding Officer
Engineer Research and Development Laboratories
Fort Belvoir, Virginia

1. The subject project including the military characteristics is approved. Copies of project paper, letter of transmittal and approval sheet are inclosed for your information and guidance.

2. This project has been assigned a 2-A priority and the security classification of the project, military characteristics, and equipment during research and development is confidential.

3. Procurement of such equipment as may be required for engineering tests in connection with this project is authorized.

4. The Quartermaster Corps is authorized to furnish samples of camouflage clothing for evaluation of camouflage effectiveness, engineering and service tests required for the project.

5. Delineation of responsibility incident to camouflage clothing is established by Department of the Army Memorandum No. 30-5-3, subject: Camouflage Clothing, dated 10 March 1948.

6. Liaison with the Quartermaster Corps for the execution of this project is authorized.

BY ORDER OF THE CHIEF OF ENGINEERS:

/s/ R. L. Dean
/t/ R. L. DEAN
Colonel, Corps of Engineers
Chief, Engr Research & Development Div.
Military Operations

1 Incl
JRDB Form #1A
w/covering ltr
and approval sheet.

Classification Changed to UNCLASSIFIED
By Authority of CETC Mtg #249, Item #2144, 4 Dec 53

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON 25, D. C.

Item No. 1319
CETC Meeting #187

APPROVAL SHEET

SUBJECT: PATTERNS, CAMOUFLAGE CLOTHING, Project No. 8-31-02-004, Approval of Military Characteristics and Authorization of Project

Subcommittee Report approved by the Corps of Engineers Technical Committee, 7 May 1948.

/s/ R. L. Dean
/t/ R. L. DEAN
Colonel, Corps of Engineers
Chairman, CETC

Technical Committee Action approved, 7 May 1948.

FOR THE CHIEF OF ENGINEERS:

/s/ W. D. Luplow
/t/ W. D. LUPLOW
Colonel, Corps of Engineers
Assistant Chief of Engineers for
Military Operations

Technical Committee Action approved, 7 May 1948.

BY ORDER OF THE SECRETARY THE ARMY

/s/ Duncan Hallock
/t/ DUNCAN HALLOCK
Lt. Colonel, GSC
Research & Development Group
Logistics Division

Classification Changed to UNCLASSIFIED
By Authority of CETC Mtg #249, Item 2144

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON 25, D. C.

Item No. 1319
CETC Meeting #187

ENGNE

14 April 1948

SUBJECT: PATTERNS, CAMOUFLAGE CLOTHING, Project No. 8-31-02-004, Approval of Military Characteristics and Authorization of Project

TO: The Corps of Engineers Technical Committee

FROM: Subcommittee on Research and Development

1. The Subcommittee on Research and Development pres .ts the subject project proposal described on the inclosed Project Card for appropriate action by the Corps of Engineers Technical Committee.

2. The Subcommittee recommends:

a. Approval of Project No. 8-31-02-004, Patterns, Camouflage Clothing, and assignment to the Corps of Engineers.

b. Adoption of the Military Characteristics as listed in the inclosure.

c. Assignment of Priority 2-A to the project.

d. Security classification of the project, military characteristics, and equipment during research and development be "Confidential".

e. Procurement of such equipment as may be required for engineering tests in connection with the project.

f. The Quartermaster Corps be authorized to furnish samples of camouflage clothing for evaluation of camouflage effectiveness, Engineering and Service Tests required for the project.

FOR THE SUBCOMMITTEE:

/s/ E. F. Klinke
/t/ E. F. KLINKE
Colonel, Corps of Engineers
Assistant, Engr Research & Development Div.
Military Operations

1 Incl.
Project Card
No. 8-31-02-004.

Classification Changed to UNCLASSIFIED
By Authority of CETC Mtg #249, Item 2144

SECURITY CLASSIFICATION

1. PROJECT TITLE
PATTERNS, CAMOUFLAGE CLOTHING

4. BASIC FIELD OR SUBJECT
Counterintelligence

5. SUB FIELD OR SUBJECT NO.
Camouflage

7. CONTRACT NUMBER
Office, Chief of Engineers

7a. CONTRACTOR (NAME AND ADDRESS)
Engr. Res. & Dev. Laboratories

8. EFFECTIVE DATE:
Engr. Res. & Dev. Div., MO, OCE

9. ESTIMATED DATE OF COMPLETION
Office, Chief of Engineers; Office Chief of Army Field Forces

10. PARTICIPATION AND/OR COORDINATION
Office, Quartermaster General (C and P)

11. SECURITY CLASSIFICATION
No. 23-04-01 OCMO
No. 8-31-02-002 OCE

11. DATE OF INFO.

11. DATE OF INFO.
FY 1949 June 49
FY 1950 Dec 50
FY 1951 June 51
FY 1952

11. DATE OF INFO.
FY 1949 6
FY 1950 12
FY 1951 24
FY 1952

12.
Item No. 1319, CETC Meeting /187

13. OBJECTIVE AND JUSTIFICATION: Reduced visibility of the infantry soldier is required both day and night. Development of infrared viewing devices requires concurrent development of countermeasures. Clothing can be treated to provide reflectance values in patterns that will minimize the value of infrared aids. This project may result in an end item possessing such marked superiority over existing items that complete or extensive replacement would be justified.

14. BRIEF OF WORK TO BE DONE:
a. REFERENCES:
(1) War Department Equipment Board Report (Secret) dated 29 May 1946, Section XXI, Quartermaster Equipment para. 6b, Field or Combat Uniforms.
(2) Department of the Army Memorandum No. 30-5-3, dated 10 March 1948, Camouflage Clothing
b. OBJECTIVE:
(1) Development of patterns, color and reflectance values, which when applied to the combat uniform will render the wearer inconspicuous under all battle conditions.
c. MILITARY CHARACTERISTICS:
(1) The patterns, colors and reflectance values shall be designed so that when these camouflage elements are incorporated in the combat uniform the infantry soldier wearing the camouflage clothing will be less visible to the enemy both day and night.
d. DISCUSSION:
(1) The War Department Equipment Board Report (Secret), dated 29 May 1946 Section XXI, Quartermaster Equipment, paragraph 6b, states: "Field or combat uniform. Research should be continued to improve the design, color, and camouflage, fit and sizing of the component parts of the combat uniform."
(2) The delineation of responsibility to camouflage clothing was established by Department of the Army Memorandum No. 30-5-3, dated 10 March 1948, as the result of several conferences between representatives of the Office of the Quartermaster General and the Office, Chief of Engineers.
(3) The work being conducted under Project No. 8-21-02-002 "Camouflage Helmet Cover for Helmet Steel, M1, will provide data which should be of assistance in furthering the development of "Camouflage Clothing"

FY 1949 | FY | FY 1950 & FY | E. | I. | C.

SECURITY CLASSIFICATION

SECURITY CLASSIFICATION

1. PROJECT TITLE
PATTERNS, CAMOUFLAGE CLOTHING

(4) A soldier no longer is invisible under the cover of darkness when the enemy uses near infrared viewing devices. Such viewing devices make movements by night almost as hazardous as by day.
(5) The U. S. troops made excellent use of the snooperscope on Okinawa picking off Japanese on night patrols. It is generally believed that a good proportion of the casualties suffered by Japanese there resulted from detection of their movements at night.
(6) As it is reasonable to assume that extensive use of infrared viewing devices will be employed by the enemy in the next war, expeditious development of effective countermeasures becomes a necessity.
(7) Quartermaster Corps participation in this project consists of applying patterns and colors designed by Corps of Engineers to combat uniforms and furnishing necessary camouflage clothing for engineering tests.
(8) Agencies interested in this project, in addition to the Corps of Engineers are Army Field Forces, Quartermaster Corps

e. PLAN OF DEVELOPMENT:
(1) It is intended to conduct a series of experiments with combinations of patterns and colors values until the optimum in concealment against daytime visual and night time infrared detection is accomplished. Means developed will also be tested against other known forms of battlefield illumination.
(2) These combinations of patterns and color values will be furnished the Quartermaster Corps for incorporation into the fabric with which the camouflage clothing will be made.
(3) The finished garments furnished by the Quartermaster Corps will be given exhaustive engineering tests to evaluate the camouflage effectiveness of the clothing.
(4) When the camouflage clothing has been found to contain the various characteristics necessary to provide adequate concealment the approved patterns will be recommended to the Quartermaster Corps for service tests.
(5) The finished camouflage clothing when used with the helmet cover will provide a suitable base to which natural foliage or artificial garnishing material may be added, and will provide the infantry soldier concealment at close range for patrol, observation and sniper missions.
(6) Being a participating project, the responsibilities for camouflage clothing being divided between the Quartermaster General and the Chief of Engineers close liaison with the Quartermaster Corps will be maintained throughout the life of the project.
(7) The facilities of industry and other non-government agencies will be engaged to undertake appropriate phases of the development.

OVER.

Exhibit 2

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON 25, D. C.

ENGNF 18 December 1950

SUBJECT: Personal Camouflage Requirements

TO: Chief, Army Field Forces
Fort Monroe, Virginia
ATTN. G-4

1. through 3. (Ed. note: omitted as not pertinent.)

4. It is understood that Office, Chief of Army Field Forces for logistical reasons has selected a compromise color of dark greenish yellow, "Munsell" 10 Y 3/3 for the wet cold uniform as the least objectionable color. Also that this color would cover approximately 90% of the uniform requirement. The remaining 10% requirements would include special mission and special area uniforms as well as camouflage color patterned uniforms.

5. (Ed. note: omitted as not pertinent.)

6. The following constitutes this office's interpretation of the camouflage requirements stipulated in the various meetings noted above and the requirements set forth in the Report of the Army Equipment Board (1950) and the preliminary Report of the Department of the Army Uniform Board 29 April 1949.

a. The personal items with which this correspondence concurs for which camouflage coloration is considered to be necessary are:

(1) Clothing, Combat.

(2) Helmet Covers.

(3) Towels, Handkerchiefs and Cotton Underwear.

(4) Webbing, etc.

(5) Special protectional items, i.e., Poncho, Gloves, Mosquito head nets, and Insect Bars.

(6) Tentage, Small Man-Carried.

b. General Principles.

(1) Camouflage Coloration should be applied to all components of the uniform habitually worn or capable of being worn as an outer garment except for items such as button-in insets when lack of closures preclude their being worn as outer garments.

(2) Camouflage coloration should be effective against visual and infrared, direct and indirect observation from the ground and low flying aircraft.

(3) Camouflage coloration should be equally effective in the attack and defense phases of combat.

(4) Camouflage coloration cannot be sacrificed for recognition requirements.

(5) Camouflage coloration for specific items should be based primarily on geographical rather than strictly climatic considerations.

(6) Camouflage coloration of the combat ensemble, in the visual spectrum is required from a minimum critical distance of 150 to 1000 yards and should be designed to reduce the conspicuousness of the individual in the open pasture type of terrain as opposed to the closed wooded type of terrain.

7. As indicated in the meeting held at Office, Chief of Army Field Forces on 25 October 1950, it is considered desirable for your office to summarize in a single document the required general military characteristics for personal camouflage.

8. It is requested that the aforegoing to be reviewed and that your comments and/or concurrence be transmitted to this office.

FOR THE CHIEF OF ENGINEERS:

/s/ Lloyd L. Rall
for D. G. HAMMOND
Lt Colonel, Corps of Engineers
Chief, Engr Res & Development Div
Military Operations

ATDEV-11 384.6(C) (18 Dec 50) 1st Ind

Office, Chief of Army Field Forces, Fort Monroe, Virginia 3 January 51

TO: Chief of Engineers, Department of the Army, Washington 25, D. C.

1. The statement contained in paragraph 4 of basic is confirmed. The colors were chosen for the reasons stated therein.

2. The interpretation made by your office of the camouflage requirements of the Army in the field as set forth in paragraph 6 of basic is concurred in and is a clear statement of the required general military characteristics for personal camouflage.

3. It is the recommendation of this office that the statement of requirements contained in paragraph 6 of basic form the basis for future research and development in the field of camouflage for combat uniforms and individual equipment.

FOR THE CHIEF OF ARMY FIELD FORCES:

5 Incls
n/c

L. E. BARBER
Lt Col, AGC
Asst Adj Gen

ENGNF (18 Dec 50) 2nd Ind

Office of the Chief of Engineers, Washington 25, D. C. 10 January 51
TO: Commanding General, The Engineer Center, Fort Belvoir, Virginia

For information and guidance of the Engineer Research and Development Laboratories in connection with future Research and Development in the field of Camouflage for combat uniforms and personal equipment.

BY ORDER OF THE CHIEF OF ENGINEERS:

D. G. HAMMOND
Lt Colonel, Corps of Engineers
Chief, Engr Res & Development Div
Military Operations

ARMY FIELD FORCES BOARD NO. 3
Fort Benning, Georgia

Exhibit 1

GNBCG 421

26 Nov 52

SUBJECT: Ensemble, Hot-Wet

THRU: Chief of Army Field Forces
Fort Monroe, Virginia
ATTN: ATDEV-11

TO: Department of the Army
Research & Development Division
Washington 25, D. C.

In accordance with Department of the Army policy to expedite development and to eliminate unnecessary expenditure of funds, recommend that early consideration be given to recommendations contained in Incl 1 to Ltr, GNBCG 421 (P-2500), AFF Board No. 3, 17 Nov 52, Subject: "Tentative Report of Project No. 2500, Test of Uniform, Combat Hot-Dry, EX-52-2" (RESTRICTED Security Information). Pertinent recommendations are:

a. "No further consideration be given to separate uniforms for hot-wet and hot-dry climates."

b. "The requirement for one hot weather uniform for use under both hot-wet and hot-dry climatic conditions be established."

/s/ William J. Eyerly
WILLIAM J. EYERLY
Colonel, Artillery
Acting President

Exhibit 4

DEPARTMENT OF THE ARMY
Office of the Chief of Engineers
Washington, D. C.

ENGNF(G/8-31-02-004) 3 June 1953

SUBJECT: Camouflage Hot-Dry, Hot-Wet Uniforms

TO: Commanding Officer
Engineer Research & Development Laboratories
Fort Belvoir, Virginia

1. Reference is made to inclosed copy of Restricted Disposition Form, Comment No. 1 from G-4 to the Chief of Engineers, file G4-F3-31985, Subject: "Uniforms, Hot-Wet and Hot-Dry Climates," dated 21 May 1953.

2. Disposition form referenced in paragraph 1 above is forwarded for your guidance and appropriate action.

3. Information received 1 June 1953 from Office of the Quartermaster General indicates that the Quartermaster intends conducting tests from 1 July to 1 September 1953. It is requested that ERDL conduct its tests concurrently and in coordination with The Quartermaster Board, Camp Lee, Virginia. Direct liaison with that Board is authorized. Copies of correspondence to and from the Board should be transmitted to this office.

BY COMMAND OF MAJOR GENERAL STUROIS:

/s/ Walter W. Flynn
for C. T. NEWTON
Colonel, Corps of Engineers
Chief, Engr Res & Dev Div
Military Operations

1 Incl
CY DF fr G-4,
21 May 53

Uniforms, Hot-Wet and Hot-Dry Climates

G4-Fs Col Triplet/54585/mf

The Quartermaster General G4
Chief of Engineers

1. Reference is made to letter, subject as above, file G4/F3 25073, dated 28 April 53, which stated a conference would be held on 14 May 1953.

2. The agreements reached at the conference referred to in paragraph 1 above, with the concurrence of ACofS, G3 DA, OCAFF, QMG and CofE are:

a. The present utility cap, jacket and trousers (HBT), O.G. 107 color stays for utility and temperate zone combat uniform.

b. The Quartermaster Corps will:

(1) Continue work on design and cloth.

(2) For desert (Hot-Dry) use utilize poplin cloth in shade (Tan) #112.

(3) The jungle (Hot-Wet) uniform will be continued in poplin cloth, shade (Olive Green) #116.

c. The Corps of Engineers will continue work on color in coordination with AFF and QMC.

d. At the end of summer tests at Yuma and jungle tests in Panama by the QMC, another conference will be called to reevaluate the results, and the one-uniform concept for hot climates will be reexamined.

e. The Corps of Engineers will investigate the camouflage of webbing, helmets and body armor, to conform to camouflage colors of uniforms.

f. Joint Quartermaster and Engineer tests with AFF observers should not preclude the establishment of a study group of QMC, CofE, and AFF membership, similar to that now working on load carrying equipment.

g. Chief of Army Field Forces will immediately furnish QMC with design changes desired on Hot-Wet and Hot-Dry uniforms.

3. It is requested that your office take the necessary action in accordance with paragraph 2 above.

BY DIRECTION OF THE ASSISTANT CHIEF OF STAFF, G4:

Copies furnished:
ACofS, G3
CAFF, ATTN: DEV-11

W. S. TRIPLET, Colonel, GS
Chief, Development Br, R&D Div

Incl 1

DEPARTMENT OF THE ARMY
Office of the Chief of Engineers
Washington 25, D. C.

Exhibit 5

ENGNF (E-8-31-02-004) 1 July 1953

SUBJECT: Uniforms, Hot-Wet and Hot-Dry Climates

TO: Commanding Officer
Engineer Research & Development Laboratories
Fort Belvoir, Virginia

1. Reference is made to Restricted Disposition Forms, Comment No. 1 from G4, General Staff, Department of the Army to the Quartermaster General and the Chief of Engineers, file G4/P3, subject as above, dated 21 May 53.

2. At a meeting held on 26 June 1953 in the Pentagon attended by Colonel W. S. Triplet, Lt. Col. W. L. Lewis, G4, R&D Div; Mr. L. J. Eaton, OCE and Mr. R. L. Thornton, ERDL, paragraph 2f of Disposition Form, Comment No. 1 referenced in paragraph 1 above was interpreted to imply that the Corps of Engineers would have a qualified colorist on hand periodically at Yuma in order that Quartermaster Corps questions on matters of color could be answered.

3. It is requested therefore that ERDL have a qualified camouflage technician at Yuma for at least two (2) working days within each fourteen (14) calendar day period for the duration of the joint tests and for an additional time deemed necessary by the Quartermaster Corps project officer.

4. It is requested that a detailed overall cost estimate for conducting these tests, chargeable to Project No. 8-31-02-004, Patterns, Camouflage Clothing, be forwarded so as to reach the office, Chief of Engineers, ATTN: ENGNF, not later than 6 July 1953.

5. This confirms requests made by telephone on 29 June 1953.

BY COMMAND OF MAJOR GENERAL STURGIS:

C. T. NEWTON
Colonel, Corps of Engineers
Chief, Engr Res & Development Div
Military Operations

Exhibit 6

SUBJECT: Equipment, Supplies, and Services for Panama Camouflage Tests

ENGNF(C/02-004) (15 Oct 53) 1st Ind

Office of the Chief of Engineers, Washington 25, D. C., 5 November 1953

TO: Commanding Officer, Engineer Research and Development Laboratories
Fort Belvoir, Virginia

1. Reference is made to the meeting held at the Office of the Quartermaster General on 3 November 1953 attended by representatives of OCE and ERDL at which the following was discussed:

a. The ERDL test group will share the office, work area and storage space assigned to the R&D Evaluation Agency of the Quartermaster Corps at test area.

b. The Quartermaster Corps R&D Evaluation Agency will furnish 6 men for the use of the ERDL test group.

c. The following support is being requested of the theater to meet the requirements of the ERDL test group tests scheduled to begin approximately 1 December 1953 and ending approximately 20 December 1953.

(1) Quarters and messing facilities for the three ERDL test groups and the two truck drivers requested of the theater.

(2) One 1/4 ton truck (jeep), one 3/4 ton truck with 1-ton trailer.

(3) Drivers for the two vehicles in 2 above.

(4) The use of a liaison type plane with pilot for the purpose of taking camouflage aerial photographs. It is estimated that the necessary photographic coverage can be conducted if plane is made available on a day basis, for a total of three days, not necessarily consecutive days because photographic coverage is dependent upon factors that cannot be determined in advance. In this connection the ERDL test group will supply the cameras and necessary special type films.

2. The theater is being requested to grant clearance and second air priority to include 35 pounds excess baggage per each of the three men.

3. The Office of The Quartermaster General suggests that any shipment of equipment not being carried with the personnel be shipped c/o Post Quartermaster, Fort Sherman, Panama Canal Zone for the Engineer Research and Development Camouflage test team, Attention of the Quartermaster test team.

4. Contingent upon the concurrence of the theater, this office approves the travel of Mr. John Hopkins, Mr. Edward Bierly, and Mr. Sidney Feldman of the ERDL to travel to the Panama Canal Zone for a period of approximately 30 days. These tests are scheduled to begin on or about 1 December 1953 for the purpose of conducting camouflage color experiments in coordination with the Quartermaster Corps, R&D Evaluation Agency test team on the cooperative tests of Ensemble, Hot-Weather QMBT-1252-53100.

5. Upon arrival at the Panama Canal Zone the ERDL test team will report to the Army representative at the Headquarters in which they are performing duty. Other agency to be contacted will be the Quartermaster Corps, Research and Development Evaluation Agency test team for the cooperative testing with respect to the camouflage coloration aspects of the tests.

6. In conformance with the current austerity program every effort should be made to complete all required tests during the December 1953 test period rather than continue these tests during the spring season of 1954.

7. It is requested that suggested color for clothing as the result of these tests be forwarded so as to reach the Office, Chief of Engineers, Attn: ENGNF, not later than 1 February 1954.

BY COMMAND OF MAJOR GENERAL STURGIS:

/s/ C. T. NEWTON
Colonel, Corps of Engineers
Chief, Engr Res & Dev Div

APPENDIX B

EQUIPMENT USED IN FIELD TESTS

Item	Quantity Desert	Quantity Jungle
Adapter, film pact 4x5	0	2
Adapter, lens hood	0	3
Armor, vest, M-52A, size medium	4	2
Athletic equipment for recreation, set	1	0
Attachment, color, Harrison, T/CE DW model exposure meter	1	1
Axe, chopping, single bit	1	0
Bag, canvas, water, 2 gal.	4	0
Bag, film changing	1	1
Bag, sleeping, wool	2	0
Bandoleers, ammo. - wood block loaded	5	5
Batteries, flash	0	6
Battery assembly - 3 nonspill storage cells sig stock No. BB-241/U for snipersoope	0	2
Belt, cartridge, cal. .30, dismt. M-1932	8	6
Binocular, stereo-prism 6x30 w/case	1	1
Binocular, stereo-prism 7x50 w/case	1	0
Blanket, wool OD M-1943	10	0
Brushes, paint, 2"	4	0
Bulbs, flash, GE 50, pkg	5	10
Cable, flash	1	2
Camera, 35mm Argus C-3	1	1
Camera, motion picture, cine Kodak 16mm, Royal, w/f). 1" FL lens w/carrying case	1	1
Camera, PH-7E, Anniversary Model	0	1
Camera, speed graphic, 4x5	1	1
Canteen, M-10, aluminum	4	6
Cape, exp., camouflage	0	5
Carrier, intrenchment tool, combat	8	0
Carryall, vehicle, 6 passenger	1	0
Case, water repellent, bag sleeping M-45	2	2
Case, water repellent, bag, sleeping, M-1945	2	0
Chair, folding, steel	6	0
Chair, folding, wood and metal	6	0
Cloth, exp., samples. 1 yd x 3 yds approx. solid shades and patterns	0	8
Compass, box dial, 3' x 3' Dietzgen	1	0
Cot, canvas, folding	6	0
Cover, canteen, dismt. M-1910	8	0
Covers, helmet, exp. burlap in 4 colors	20	18
Cup, canteen, CRS	4	6

Item	Quantity Desert	Jungle
Cloth, focusing	1	1
Drum, inflammable, liquid gasoline, steel, 5-gal. cap.	3	0
Film, 16mm, Kodachrome, ft.	2700	3300
Film, 35mm, Kodachrome for stereo camera, roll	5	3
Film, Ektachrome, 4x5 sheet	41	35
Film, infrared, 4x5 sheet	18	15
Film, super xx, 4x5 sheet	58	40
Filters, set, Wratten series VI.	1	1
Finder, range, M-7 w/tripod 1 meter base	1	0
Flash gun, Graflex #37	1	1
Flashlight, 2 cell	5	5
Grey scales 9 step set, 1x2 ft ea. celolex	1	1
Hammer, carpenters	1	0
Hatchet	1	0
Haversack	0	3
Helmet, liners	4	6
Helmet, steel M-1	4	6
Helmet, sun	10	0
Holder, film, PH81 - cut film 4x5	15	15
Jack, hydraulic, 3 ton, w/handle	2	0
Jug, insulated, 1-gal. cap., w/spigot	2	0
Kit, first aid, motor, vehicle, 24 unit	1	0
Kit, snake bite, suction	1	1
Lens, 127mm in Kodak shutter supermatic	1	1
Light corrector disks, Harrison series VI complete set of 22, #8 1/8 to C8 - set	1	1
Looker, trunk	6	0
Machette, 18" M1942 Style B, w/Sheath	1	2
Marker, minefield	6	0
Meter, exposure, Mdl, GE-DW-68	1	1
Meter, exposure, Weston	1	1
Mount, filter, lens hood & holder Ph 105A	2	3
Net, helmet, w/band	0	1
Pack, field, cargo, M-45	8	6
Pack, field, combat, M-45	8	6
Padlock, master No. 5, 2 in.	3	0
Pails, 14 qt.	4	0
Paint, camouflage exp, can, Freon gas, 4 colors	0	12
Paint, face, camouflage, stick 2 colors	0	2
Pistol, Pyrotechnic, w/flares	2	0
Pole, upright 12' 3"	2	0
Pouch, first aid packet, M1942	8	6
Radio set, AN/PRC-6	2	0
Range finder, coupled to 4x5 speed graphic camera	1	1
Ration, operational "e" case	1	0

Item	Quantity Desert	Jungle
Rifle cal. .30 M1, w/sling class x.	4	0
Saw, hand, crosscut	1	0
Shovel, gen purpose, round point type IV	1	0
Shovel, intrenching M-43	4	6
Scissors, pr	0	1
Slate, photo information	2	2
Snipersoope, 20,000 V, infrared set #1, w/case	0	1
Snipersoope, photographic assembly w/lens - viewer, powerpack, tripod & case	0	1
Spools, takeup 16 mm, w/can, film	4	4
Stamps	2,500	0
Station wagon, Buick, 1951, w/steel cage	1	0
Suspenders pack, field, cargo & combat	8	6
Tablets, salt, box of 50	1	0
Tape, masking, roll	0	2
Tent, shelter, half, new type, complete w/pins & poles	8	8
Tissue, lens, pkg	2	2
Tripod, quick set	1	1
Truck, $\frac{1}{4}$ ton, 4x4	1	1
Truck, 3/4 ton, 4x4	2	1
Typewriter	1	0
Uniform, combat, lightweight ensemble T-53-1 shade OG107 consisting of 1 cap, 1 shirt, 1 pr trousers	1	1
Uniform, combat, lightweight ensemble T-53-2 shade Tan 118 as above	4	1
Uniform, combat, lightweight ensemble T-53-3 shade Green 116 as above	1	4
Uniform, combat, lightweight ensemble T-53-1 shade Khaki No. 1 as above	1	1
Uniform, exp., flock pattern on nylon	0	1
Uniform, exp., RPS-1	0	1
Uniform, exp., solid visual shade OG107 infrared p ttern ST	0	1
Uniform, exp., ST pattern various color combinations	0	3

APPENDIX C

TABULATED RESULTS OF DESERT OBSERVATIONS

Table VII. Test Series No. 1; Khaki No. 1 Uniform

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
			a. Front Lighting			
Rio Puerco	2000	2000	700	775	1100	500
	2000	2000	1000	775	775	600
	2000	2000	900	1000	1000	500
	1700	2000	750	500	550	400
	2000	-	1100	900	900	550
Marble Canyon	1600	1600	600 K	1060	1060	400 K
	1600	1600	400 K	1200	1400	300 K
	1100	1400	500 K	600	900	400 K
	1600	1600	-	900	1100	-
Rosamond	3000	3000	2200	2000	2000	1350
	1600	3000	1000	900	1400	600
	1900	2400	1275	-	-	-
Westmorland	-	-	-	600	600	500
	-	-	-	700	700	500
	-	-	-	700	850	500
	-	-	-	700	-	-
			b. Side Lighting			
Rio Puerco	1500	1500	-	1100	1200	-
	1700	1700	-	1400	1400	-
	1950	1950	-	1100	1200	-
	1900	1900	-	-	1200	-
Rosamond	2125	2625	1075	2125	2125	775
	2100	2600	1100	1200	1875	800
	2125	2125	900	2125	2125	775
	1700	1900	1700	600	1500	600
	2300	2300	1700	1700	1800	700
	2300	2300	1700	1700	1800	700
	1600	1600	1700	900	1400	600
	1700	1800	1700	600	1000	600
Westmorland	1250	1250	600	850	950	500
	950	1200	700	800	1000	400
	1150	1200	600	600	850	500
	1500	1500	800	900	900	600

Tabl. VII (cont'd)

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
c. Rear Lighting						
Marble Canyon	1200	1400	800 K	400	1200	200 K
	1700	1700	1450 K	1075	1200	750 K
	1600	1600	1425 K	750	1400	400 K
	1600	1600	1425 K	750	1400	-
	1600	1640	1470	1100	1420	500
	1800	1800	1500 K	1300	1500	600 K
	1800	1800	1500 K	1600	1600	500 K
Rosamond	2725	3250	1700	1475	2725	850
	2725	3250	1700	1475	2725	850
	3500	3500	-	1250	1300	850
	3500	3500	-	1200	2200	-

KEY: S = Standing
W = Walking
P = Prone
K = Kneeling

NOTE: All values in yards.

Table VIII. Test Series No. 1; Tan 112 Uniform

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
a. Front Lighting						
Rio Puerco	2000	2000	850	775	900	500
	2000	2000	700	575	575	550
	2000	2000	900	900	560	600
	1400	2000	750	600	900	400
	2000	-	1100	900	900	650
Marble Canyon	1600	1600	600 K	1050	1050	300 K
	1600	1600	400 K	1200	1400	400 K
	1100	1600	500 K	600	900	400 K
	1600	1400	-	900	1100	-
Rosamond	2400	2400	2200	2000	2000	1350
	1600	3000	1000	900	1400	600
	1500	2100	1275	-	-	-
Westmorland	-	-	-	700	600	500
	-	-	-	600	700	500
	-	-	-	700	850	500
	-	-	-	700	-	-
b. Side Lighting						
Rio Puerco	1750	1750	-	1100	1200	-
	1700	1700	-	1400	1400	-
	1600	1600	-	1100	1200	-
	1700	1800	-	-	-	-
Rosamond	2125	2600	1075	2175	2125	775
	2100	2600	1150	1200	1800	800
	2125	2125	900	2125	2125	775
	2020	2210	1370	1480	1650	690
	1700	1900	1700	750	1500	400
	2300	2300	1700	1700	700	700
	2300	2300	1700	1700	1800	700
	1600	1600	1700	900	1400	600
	1700	1800	1700	600	1000	600
Westmorland	1250	1250	700	800	950	500
	950	1200	600	800	1000	400
	1200	1300	800	600	850	500
	1400	1400	600	900	900	600

Table VIII (cont'd)

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
			c. Rear Lighting			
Marble Canyon	1200	1400	800 K	400	1200	400 K
	1700	1700	1450 K	1075	1225	750 K
	1600	1600	1425 K	750	1400	400 K
	1600	1600	1425 K	750	1400	-
	1660	1690	1390	1090	1430	530
	1800	1800	1500 K	1300	1500	600 K
	1800	1800	1200 K	1600	1600	800 K
Rosamond	2725	3250	1700	1500	2725	850
	2725	3250	1700	1500	2725	-
	2500	2500	-	1250	1300	-
	3500	3500	-	-	-	-

KEY: S = Standing
W = Walking
P = Prone
K = Kneeling

NOTE: All values in yards.

Table IX. Test Series No. 1; Green 116 Uniform

Site	Detected as Objects			Identified as Man		
	S	W	F	S	W	F
			a. Front Lighting			
Rio Puerco	2000	2000	800	775	1200	500
	2000	2000	1000	575	850	575
	2000	2000	900	900	900	600
	1900	2000	750	600	650	650
	2000	-	1100	900	900	600
Marble Canyon	1600	1600	600 K	1050	1050	400 K
	1600	1600	500 K	1200	1400	300 K
	1300	1500	500 K	900	1000	400 K
	1600	1600	-	975	1300	-
Rosamond	3000	3000	2200	2000	2000	1350
	2400	3000	1000	1000	1600	600
	2000	3000	1350	-	1275	-
Westmorland	-	-	-	800	600	600
	-	-	-	600	700	650
	-	-	-	800	850	500
	-	-	-	700	-	-
			b. Side Lighting			
Rio Puerco	1800	1850	-	1200	1400	-
	1700	1700	-	1400	1400	-
	1950	1950	-	1100	1200	-
	1800	1900	-	-	1400	-
Rosamond	2125	2625	1075	2125	2125	750
	2200	2700	1100	1200	1800	800
	2125	2125	900	2125	2125	750
	1700	1900	1700	750	1500	600
	2300	2300	1700	1700	1800	700
	2300	2300	1700	1700	1800	700
	1700	1900	1700	900	1400	600
Westmorland	1300	1300	800	900	950	500
	1300	1400	700	900	1100	600
	1600	1400	800	700	1050	500
	1300	1600	800	900	900	600

Table IX (cont'd)

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
			c. Rear Lighting			
Marble Canyon	1400	1500	1200	800	1300	400
	1700	1700	1450	1075	1225	700
	1625	1625	1425	750	1400	400
	1625	1625	1425	750	1400	-
	1800	1800	1500	1300	1500	600
	1800	1800	1200	1600	1600	500
Rosamond	2725	3250	1700	1500	2725	850
	2725	3250	1700	1500	2725	
	3500	3500	-	1250	1300	-
	3500	3500	-	-	-	-

KEY: S = Standing
W = Walking
P = Prone
K = Kneeling

NOTE: All values in yards.

Table X. Test Series No. 1; Olive Green 107 Uniform

Site	Detected as Objects			Identified as Men		
	B	W	P	B	W	P
a. Front Lighting						
Rio Puerco	2000	2000	800	775	1200	500
	2000	2000	1100	575	775	575
	2000	2000	900	900	650	600
	1900	2000	750	600	650	600
	2000	-	1100	900	900	650
Marble Canyon	1600	1600	600	1050	1050	400
	1600	1600	500	1200	1400	300
	1300	1500	500	900	1000	400
	1600	1600	-	975	1300	-
Rosamond	3000	3000	2200	2000	2000	1350
	2400	3000	1000	1000	1600	600
	2000	3000	1350	-	1275	-
Westmorland	-	-	-	800	600	600
	-	-	-	600	700	650
	-	-	-	800	850	500
	-	-	-	700	-	-
b. Side Lighting						
Rio Puerco	1800	1850	-	1200	1400	-
	1700	1700	-	1400	1400	-
	1900	1900	-	1100	1200	-
	1800	1800	-	-	1400	-
Rosamond	2125	2625	1075	2125	2125	775
	2200	2700	1000	1200	1800	800
	2125	2125	900	2125	2125	775
	1700	1900	1700	750	1500	600
	2300	2300	1700	1700	1800	700
	2300	2300	1700	1700	1800	700
	1700	1900	1700	900	1400	600
	1700	1800	1700	800	1400	900
Westmorland	1300	1300	800	800	950	500
	1300	1400	800	900	1100	600
	1400	1500	800	700	1050	600
	1600	1600	800	900	900	600

Table X (cont'd)

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
			c. Rear Lighting			
Marble Canyon	1400	1500	1200 K	800	1300	400
	1700	1700	1450 K	1075	2225	750
	1600	1600	1425 K	750	1400	400
	1600	1600	1425 K	750	1400	-
	1800	1800	1500	1300	1500	600
	1800	1800	1200	1600	1600	500
Rosamond	2725	3250	1700	1475	2725	850
	2725	3250	1700	1475	2725	-
	3500	3500	-	1250	1300	-
	3500	3800	-	-	-	-

KEY: S = Standing
W = Walking
P = Prone
K = Kneeling

NOTE: All values in yards.

Table XI. Test Series No. 2; Khaki No. 1 Uniform

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
a. Front Lighting						
Rio Puerco	2000	2000	1000	750	750	300
	1300	1300	800	950	950	950
	2000	2000	850	950	950	900
	1200	1200	800	1000	1300	800
	2900	2900	1100	1800	2500	700
	2800	2800	1100	1500	1700	550
	2400	2400	1000	1000	1000	550
Marble Canyon	1500	1500	600 K	900	900	350 K
	800	1200	700 K	600	600	400 K
	800	1000	525 K	800	800	600 K
Rosamond	2300	2300	1400	800	1200	700
	1000	1200	1300	600	1200	700
	1200	1200	1400	600	1000	400
	2300	2300	1000	1000	1000	700
	3700	3700	1400	900	1400	800
Westmorland	-	-	-	650	650	400
	-	-	-	700	800	475
	-	-	-	800	000	500
	-	-	-	550	650	300
b. Side Lighting						
Rio Puerco	2000	2050	1200	850	850	400
	1950	1950	1200	1200	1500	500
	1600	1900	1200	850	1050	500
	-	-	1200	1200	850	500
	-	-	1200	1000	1050	500
Marble Canyon	1000	1100	700	1000	1000	400
	1600	1600	1000	1200	1500	600
	1600	1600	1000	1100	1100	500
	1850	1850	-	-	1400	-
	1700	1800	1700	1200	1600	1000
	1800	1800	1500	1300	1500	600
Rosamond	2300	2400	1200	1200	1800	800
	2300	2400	1200	1000	1800	700
	2800	2800	1400	1100	1800	1000
	2400	2800	1200	1000	1500	600

Table XI (cont'd)

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
Westmorland	1100	1300	700	700	900	500
	900	1000	500	700	900	400
	1000	1000	800	700	700	600
	1400	1400	600	800	1000	400
	1100	1300	600	700	1000	-
			c. Rear Lighting			
Marble Canyon	1700	1800	1500	900	1100	200
	1700	1800	1600	1200	1450	500
	1700	1700	1300	1300	1500	600
	1800	1800	1600	1100	1200	600
Rosamond	2400	2400	900	1100	1600	800
	2400	2400	900	1100	1600	800
	1800	2600	900	1000	1300	800
	1800	2000	1000	900	1100	500
	2400	2400	900	1400	1600	800
	1600	2200	950	800	1100	600

KEY: S = Standing
W = Walking
P = Prone
K = Kneeling

NOTE: All values in yards.

Table XII. Test Series No. 2; Tan 112 Uniform

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
a. Front Lighting						
Rio Puerco	1900	1900	1000	750	750	300
	2000	2000	850	950	950	900
	1900	1900	900	950	950	900
	2000	2000	1000	1100	1300	700
	2900	2900	1100	1800	2500	700
	2850	2850	1100	1500	1700	550
	2400	2400	1100	1000	1000	550
Marble Canyon	1500	1500	525 K	900	900	350 K
	800	1200	600 K	600	600	400
	800	1000	700 K	800	800	500
Rosamond	2300	2300	1400	800	1000	700
	1400	1800	1700	600	1200	700
	1200	1200	1400	600	1000	400
	2100	2100	1200	1000	1000	700
	3700	3700	1400	900	1400	800
Westmorland	-	-	-	650	650	400
	-	-	-	700	800	475
	-	-	-	800	800	500
	-	-	-	550	650	300
b. Side Lighting						
Rio Puerco	2000	2000	1200	1150	1150	500
	1950	1950	1100	850	850	450
	1600	1800	1100	1100	1400	500
	-	-	1100	650	650	500
	-	-	1100	1300	1350	500
Marble Canyon	1000	1100	800 K	1000	1000	400
	1600	1600	1000 K	1200	1500	600
	1600	1600	900	1100	1100	500
	1850	1850	-	-	1400	-
	1700	1800	1700	1200	1600	800
	1800	1800	1500	1300	1500	600
Rosamond	2300	2400	1200	1200	1800	800
	2300	2400	1200	1000	1800	700
	2800	2800	1400	1200	1800	1000
	2400	2300	1200	1000	1500	600

Table XII (cont'd)

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
Westmoreland	1000	1200	700	700	900	500
	1000	1000	500	900	900	400
	850	1000	800	800	700	600
	1400	1400	600	700	1000	400
	1100	1300	600	700	1000	-
			c. Rear Lighting			
Marble Canyon	1700	1800	1500	900	1100	200
	1700	1800	1600	1100	1450	500
	1700	1700	1300	1200	1500	600
	1800	1800	1600	1300	1200	600
Rosamond	2400	2400	900	1100	1600	800
	2400	2400	900	1100	1600	800
	1800	2600	900	1000	1300	800
	1800	2200	1000	900	1100	500
	2400	2400	900	1400	1600	800
	1600	2200	950	800	1100	600

KEY: S = Standing
W = Walking
P = Prone
K = Kneeling

NOTE: All values in yards.

Table XIII. Test Series No. 2; Green 116 Uniform

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
			a. Front Lighting			
Rio Puerco	2200	2200	1100	750	900	500
	2000	2000	1200	1100	1100	700
	2000	2000	1150	1100	1200	550
	2000	2000	1200	1100	1300	750
	2900	2900	1100	1800	2500	850
	2900	2900	1100	1500	2300	800
	2600	2600	1400	1100	1100	800
Marble Canyon	1500	1500	800	1200	1200	800
	1500	1500	800	600	800	400
	1600	1600	800	800	800	600
Rosamond	3500	3500	1500	1000	1400	800
	2600	3000	1700	1000	1700	800
	2500	3000	1700	800	1400	800
	3800	3800	1000	1200	1200	700
	3800	3800	1400	1000	1400	800
Westmorland	-	-	-	500	500	400
	-	-	-	700	800	475
	-	-	-	800	800	500
	-	-	-	800	800	475
			b. Side Lighting			
Rio Puerco	2000	2050	1200	1150	1150	500
	1950	2050	1375	850	900	500
	1700	1900	1100	1100	1400	500
	"	"	1500	1000	1000	500
	"	"	1100	1300	1350	500
Marble Canyon	1500	1600	1000	1100	1200	600
	1600	1600	1000	1200	1500	800
	1600	1600	1000	1200	1200	500
	1850	1850	-	-	1400	-
	1700	1800	1700	1200	1600	1100
	1800	1800	1500	1300	1500	600
Rosamond	2300	2800	1600	1200	1800	800
	2300	2400	1200	1000	1800	700
	2600	2800	1500	1200	1800	1000
	2400	2800	1200	1000	1500	600

Table XIII (cont'd)

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
Westmorland	1400	1500	800	700	900	600
	1000	1400	600	850	1000	400
	1300	1350	800	800	800	600
	1500	1500	600	900	1100	600
	1350	1350	900	700	1000	-
			c. Rear Lighting			
Marble Canyon	1800	1800	1800	900	1200	500
	1800	1800	1600	1100	1450	500
	1700	1700	1300	1300	1500	700
	1800	1800	1600	1200	1200	600
Rosamond	2400	2400	900	1100	1600	800
	2400	2400	900	1100	1600	800
	1800	2600	900	1000	1400	800
	1800	2200	1000	900	1100	500
	2400	2400	900	1400	1600	800
	1600	2200	950	900	1100	600

KEY: S = Standing
W = Walking
P = Prone

NOTE: All values in yards.

Table XIV. Test Series No. 2; Olive Green 107 Uniforms

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
a. Front Lighting						
Rio Puerco	1900	1900	1300	900	750	500
	2000	2000	1200	1075	1075	800
	2000	2000	1300	1000	1100	900
	2000	2000	1300	1000	1300	650
	2900	2900	1100	1800	2500	700
	2900	2900	1100	1500	2300	750
	2600	2600	1400	1100	1100	550
Marble Canyon	1500	1500	800	1200	1200	800
	1500	1500	800	600	800	400
	1600	1600	800	800	800	600
Rosamond	3500	3500	1500	1000	1200	800
	2600	3000	1500	1000	1700	800
	2500	3050	1700	800	1400	800
	3800	3800	1200	1200	1200	700
	3800	3800	1400	1000	1400	800
Westmorland	-	-	-	500	500	500
	-	-	-	700	800	475
	-	-	-	800	800	500
	-	-	-	800	800	475
b. Side Lighting						
Rio Puerco	2050	2050	1100	1150	1150	500
	1950	2000	1100	750	900	500
	1700	1900	1100	1100	1300	500
	-	-	1600	1000	1000	500
	-	-	1100	1300	1350	500
Marble Canyon	1500	1600	1000	1100	1200	600
	1600	1600	1000	1200	1500	800
	1600	1600	1000	1200	1200	500
	1850	1600	-	-	1400	-
	1700	1800	1700	1300	1600	1100
	1800	1800	1500	1200	1500	600
Rosamond	2300	2800	1200	1200	1800	800
	2300	2400	1200	1000	1800	700
	2800	2800	1500	1200	1800	1000
	2400	2800	1200	1000	1500	600

Table XIV (cont'd)

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
Westmorland	1500	1600	800	700	900	600
	1000	1400	800	850	1000	400
	1300	1300	600	800	800	600
	1500	1400	600	900	1100	600
	1350	1350	900	700	1000	-
			c. Rear Lighting			
Marble Canyon	1800	1800	1800	900	1200	700
	1800	1800	1600	1200	1450	600
	1700	1700	1300	1400	1500	700
	1800	1800	1600	1100	1200	600
Rosamond	2400	2400	900	1100	1600	800
	2400	2400	900	1100	1600	800
	1800	2600	900	1000	1400	800
	1800	2400	1000	900	1100	500
	2400	2400	900	1400	1600	800
	1600	2200	950	800	1100	600

KEY: S = Standing
W = Walking
P = Prone

NOTE: All values in yards.

Table XV. Test Series No. 3; Tan 112 Uniform, Two with Olive-Drab Body Armor

Site	Detected as Objects			Identified as Men		
	S	W	F	S	W	F
a. Front Lighting						
Rio Puerco	1600	1600	700	1200	1400	400
	1600	2200	700	1200	1400	400
	2100	2700	700	1100	1500	400
	2100	2700	700	1100	1500	400
	1600	2100	700	900	1200	400
	1600	2200	700	900	1200	400
Marble Canyon	1300	1700	1300 K	400	400	400 K
	1300	1700	1300 K	400	800	400 K
	1300	1700	1300 K	400	1200	400 K
	1300	1700	1300 K	400	1200	400 K
	1600	1600	1200 K	700	900	-
	1600	1600	1200 K	700	900	-
	-	-	-	800	-	-
	-	-	-	800	-	-
Rosamond	2600	2600	1400	800	1000	600
	2600	2600	1300	800	1000	600
	2600	2600	1250	800	1000	500
	2600	2600	1250	800	1000	500
	2700	2300	1500	800	1300	800
	2700	2300	1500	800	1200	800
	2600	2200	1500	600	1000	600
	2600	2700	1500	600	1000	600
	2300	2600	1300	800	1000	500
	2300	2600	1300	800	1000	500
b. Side Lighting						
Marble Canyon	1700	1800	1700 K	1300	1500	700 K
	1700	1800	1700 K	1300	1500	700 K
	1800	1800	1600 K	1600	1600	800 K
	1800	1800	1600 K	1600	1600	800 K
	1800	1800	1600 K	1400	1600	-
	1800	1800	1600 K	1400	1600	-

Table XV (cont'd)

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
Rosamond	3200	3500	1700	1200	1400	900
	3200	3500	1700	1200	1400	900
	2000	2000	1800	800	1200	800
	2000	2000	1800	800	1200	800
	3400	3400	1800	800	1400	1200
	3400	3400	1800	800	1400	1200
	3000	3400	1700	1100	1400	900
	3000	3400	1700	1100	1400	900
Westmorland	800	900	500	575	700	450
	800	900	500	575	700	450
	1000	1000	-	600	800	300
	1000	1000	-	600	800	300
	900	1100	-	700	900	-
	-	1100	-	700	900	-
		c. Rear Lighting				
Marble Canyon	1700	1700	1200	1100	1200	900
	1700	1700	1200	1100	1200	900
	1200	1700	1100	1000	1000	800
	1200	1700	1100	1000	1000	800
	1700	1700	1100	1100	1300	800
	1700	1700	1100	1100	1300	800
	1400	1500	1200	700	1300	200
	1400	1500	1200	700	1300	200

KEY: S = Standing
W = Walking
P = Prone
K = Kneeling

NOTE: All values in yards.

Table XVI. Test Series No. 3; Tan 112 Uniform, Two with Tan Body Armor

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
			a. Front Lighting			
Rio Puerco	1500	1900	600	1000	1300	400
	1500	2000	600	1000	1300	400
	1900	2000	700	1100	1400	400
	2100	2200	700	1100	1500	400
	1600	2100	700	900	1200	400
	1600	2100	700	900	1200	400
Marble Canyon	1100	1300	1100	800	800	400
	800	900	500	700	700	300
	800	1200	600	800	400	700
	800	800	600	800	400	700
	1600	1600	600	700	800	-
	1600	1600	600	600	700	-
Rosamond	1500	1700	1300	700	1000	500
	1500	1800	1300	700	1000	500
	1700	1700	1250	800	1000	500
	1500	1700	1250	800	1000	500
	2300	2300	1500	800	1200	600
	2300	2300	1500	800	1200	600
	1800	2300	1500	600	1000	600
	1800	2300	1500	600	1000	600
	2600	2600	1300	800	1000	500
	2600	2600	1300	800	1000	500
			b. Side Lighting			
Marble Canyon	1700	1800	1700	1300	1500	700
	1700	1800	1700	1200	1400	600
	1800	1800	1600	1600	1600	800
	1800	1800	1600	1600	1600	800
	1800	1800	1600	1400	1600	-
	1800	1800	1600	1400	1600	-
Rosamond	3200	3500	1700	1200	1400	900
	3200	3500	1700	1200	1400	900
	2000	2000	1800	800	1200	800
	2000	2000	1800	800	1200	800
	3200	3400	1800	800	1400	1200
	3200	3400	1800	800	1400	1200
	3000	3000	1700	1100	1400	900
	3000	3000	1700	1100	1400	900

Table XVI (cont'd)

Site	Detected as Objects			Identified as Men		
	S	W	P	S	W	P
Westmorland	800	900	800	575	700	450
	800	900	800	575	700	450
	1000	1000	-	600	800	300
	1000	1000	-	600	800	300
	800	900	-	600	900	-
	800	900	-	600	900	-
			c. Rear Lighting			
Marble Canyon	1700	1700	1200	1100	1200	900
	1700	1700	1200	1100	1200	900
	1200	1700	1100	1000	1000	800
	1200	1700	1100	1000	1000	800
	1700	1700	1100	1000	1300	800
	1700	1700	1100	1000	1300	800
	1400	1500	700	400	1300	200
	1400	1500	700	400	1300	200

KEY: S = Standing
W = Walking
P = Prone

NOTE: All values in yards.

Table XVII. Color Thresholds; Desert Test Series No. 1

	Chromaticity* Detected				Color Identifiable Via Munsell System			
	Khaki	Tan	Green	OG 107	Khaki	Tan	Green	OG 107
				a. Front Lighting				
	700	500	550	500	450	250	550	150
	500	450	500	400	500	300	200	200
	200	600	300	600	400	500	500	400
	400	700	400	500	300	350	350	350
	600	600	600	600	500	300	300	500
	1000	1000	1000	1000	400	400	400	400
	1200	1300	1300	1200	500	400	500	500
	500	700	500	400	350	500	300	300
	450	500	400	300	300	350	300	300
	600	200	600	500	400	300	400	450
	600	400	600	400	250	300	250	250
					500	500	500	500
AVE	613	632	613	582	404	396	379	359
				b. Side Lighting				
	500	500	500	500	200	200	150	100
	00	400	400	400	200	200	200	200
	500	600	400	300	400	400	400	400
	600	600	600	600	350	350	250	250
	650	650	770	770	500	500	500	500
	1100	1100	1100	1100	125	125	125	125
	1200	1200	1200	1200	500	600	600	600
	600	400	500	500	500	500	500	500
	700	700	700	700	100	100	100	100
	700	700	700	700	200	200	200	200
	500	500	500	500	200	200	200	200
	500	300	300	300	-	-	-	-
	700	700	700	700	-	-	-	-
	600	600	450	200	-	-	-	-
AVE	881	762	735	706	307	307	293	289

Table XVII (cont'd)

	Chromaticity* Detected				Color Identifiable Via Munsell System			
	Khaki	Tan	Green	OG 107	Khaki	Tan	Green	OG 107
				c. Rear Lighting				
	300	300	400	400	100	100	100	100
	540	540	540	540	400	400	400	400
	630	630	630	630	540	540	540	540
	630	630	630	630	540	540	540	540
	800	800	800	800	500	500	500	500
	600	600	600	600	400	400	400	400
	200	200	200	200	200	200	200	200
	300	300	300	300	50	50	100	100
	400	400	400	400	50	50	50	50
	170	170	170	170				
AVE	457	457	467	467	309	309	314	314

* Value differences omitted. Ranges given refer to point when observer could detect hue and chroma differences.

NOTES: All test sites included.
All values in yards.

Table XVIII. Color Thresholds; Desert Test Series No. 2

Chromaticity* Detected				Color Identifiable Via Munsell System			
Khaki	Tan	Green	CC 107	Khaki	Tan	Green	CC 107
			a. Front Lighting				
1000	1000	1000	1000	50	50	300	300
710	700	560	300	500	500	500	500
700	710	450	400	380	300	400	300
700	700	700	700	200	200	250	250
630	630	630	630	400	400	400	400
500	500	1200	1200	500	500	500	500
600	600	600	600	400	400	400	400
800	800	700	500	500	500	500	500
900	900	1000	1000	500	500	300	300
400	400	300	300	300	300	200	200
600	600	600	600	500	500	500	500
800	800	800	800	300	300	300	300
300	300	400	400	700	700	700	700
800	800	800	800	500	500	500	500
800	800	800	800	300	300	300	300
500	500	500	500	"	"	"	"
			b. Side Lighting				
350	350	350	250	300	300	300	200
500	500	300	150	400	400	300	100
700	700	700	700	400	400	400	400
200	200	450	450	500	500	500	500
500	540	540	500	500	500	500	500
600	600	800	800	300	300	300	300
800	800	800	800	200	200	200	200
900	900	900	900	400	400	400	400
800	1000	1000	500	100	100	100	100
600	700	800	500	300	300	300	300
400	400	400	400	200	200	200	200
400	400	400	400	300	300	300	300
400	400	500	500	600	600	600	600
650	400	400	400	"	"	"	"
500	650	500	500	"	"	"	"
600	500	500	500	"	"	"	"
700	600	600	600	"	"	"	"
400	700	700	700	"	"	"	"

Table XVIII (cont'd)

Chromaticity* Detected				Color Identifiable Via Munsell System			
Khaki	Tan	Green	OG 107	Khaki	Tan	Green	OG 107
			c. Rear Lighting				
500	200	500	500	200	200	300	300
800	850	750	400	300	300	300	300
500	500	500	500	200	200	200	200
600	600	600	600	50	75	100	50
500	500	500	500	50	50	50	50
400	400	600	200	400	400	400	400
700	700	700	700	"	"	"	"
100	100	100	100	"	"	"	"
500	500	500	500	"	"	"	"
400	400	400	400	"	"	"	"

* Value differences omitted. Ranges given refer to point when observer could detect hue and chroma differences.

NOTES: All test sites included.
All values in yards.

Table XIX. Color Thresholds; Desert Test Series No. 3

Chromaticity* Detected		Color Identifiable Via Munsell System	
OD Body Armor	Tan Body Armor	OD Body Armor	Tan Body Armor
	a. Front Lighting		
200	200	200	200
100	100	100	100
200	200	200	200
850	850	600	600
300	300	400	400
700	100	250	250
500	500	100	100
850	850	500	500
600	500	500	800
600	600	200	200
800	800	300	300
500	500	"	"
500	800	"	"
600	600	"	"
400	400	"	"
	b. Side Lighting		
1000	1000	600	600
900	- 1000	200	200
1000	1000	100	100
200	200	300	500
800	800	200	200
900	900	400	400
500	500	100	100
500	500	100	100
	c. Rear Lighting		
300	300	200	200
300	300	200	200
200	200	200	200
200	200	200	200
300	300	300	300
300	300	300	300

* Value differences omitted. Ranges given refer to point when observer could detect hue and chroma differences.

NOTES: All test sites included.
All values in yards.

Table XX. Detection Threshold of Load Carrying Equipment and Rifles; Desert Test Series No. 1

Load Carrying Equipment								Rifle (Model Erect)			
Model Erect				Model Prone							
Khaki	Tan	Green	OG 107	Khaki	Tan	Green	OG 107	Khaki	Tan	Green	OG 107
				a. Front Lighting							
500	500	250	250	500	500	250	250	500	500	400	400
600	600	300	300	300	300	300	300	300	300	300	300
400	400	375	375	150	150	150	150	200	200	200	200
400	400	400	400	200	200	100	75	300	300	300	300
300	300	300	300		-	-	-	400	400	500	500
350	350	100	100	500 K	500 K	500 K	500 K	-	-	-	-
300	300	100	100	300 K	300 K	300 K	300 K	-	-	-	-
300	300	300	300	-	-	-	-	-	-	-	-
460	560	300	300	-	-	-	-	-	-	-	-
400	400	400	400	-	-	-	-	-	-	-	-
150	150	150	150	-	-	-	-	-	-	-	-
200	200	100	75	-	-	-	-	-	-	-	-
100	100	100	100	-	-	-	-	-	-	-	-
100	100	25	25	-	-	-	-	-	-	-	-
				b. Side Lighting							
300	300	40	40	600	600	600	600	400	400	400	400
400	400	150	150	600	600	600	600	700	700	700	700
300	400	200	100	300	300	300	300	200	200	200	200
400	400	100	100	200	200	200	200	400	400	400	550
75	75	75	75	200	200	200	200	400	400	300	300
200	200	100	100	200	200	200	200	400	400	400	400
125	125	75	75	170	170	170	170	700	700	700	700
100	100	50	50	300	300	250	250	-	-	-	-

Table XX (cont'd)

Load Carrying Equipment								Rifle (Model Erect)			
Model Erect				Model Prone							
Khaki	Tan	Green	OG 107	Khaki	Tan	Green	OG 107	Khaki	Tan	Green	OG 107
300	400	200	30	200	200	75	75	-	-	-	-
350	400	50	50	200	200	175	175	-	-	-	-
400	400	300	300	100	100	50	50	-	-	-	-
500	500	75	75	-	-	-	-	-	-	-	-
300	500	600	100	-	-	-	-	-	-	-	-
500	500	500	500	-	-	-	-	-	-	-	-
450	500	300	500	-	-	-	-	-	-	-	-
				c. Rear Lighting							
400	400	50	50	200 K	200 K	200 K	200 K	300	300	300	300
300	300	50	50	200 K	200 K	200 K	2 K	300	300	300	300
400	420	200	160	50 K	50 K	50 K	50 K	400	300	300	350
400	420	200	200	300 K	300 K	160 K	300 K	200	200	400	350
300	300	300	300	200 K	200 K	200 K	200 K	300	250	300	250
200	300	100	100	300 K	300 K	300 K	300 K	300	300	300	300
50	50	25	25	200 K	200 K	100 K	100 K	300	300	300	300
100	100	50	50	-	-	-	-	440	440	440	440

KEY: K = Kneeling

NOTE: All values in yards.

Table XXI. Detection Thresholds of Load Carrying Equipment and Rifles; Desert Test Series No. 2

Load Carrying Equipment								Rifle (Model Erect)			
Model Erect				Model Prone							
Khaki	Tan	Green	OG	Khaki	Tan	Green	OG	Khaki	Tan	Green	OG
				a. Front Lighting							
100	100	100	100	100	100	100	100	300	200	200	200
100	100	100	100	400	400	300	300	300	300	300	300
100	100	150	100	400	400	400	400	200	300	300	200
300	400	200	100	500	500	500	500	700	700	500	500
100	100	200	100	300	300	300	300	500	700	600	400
400	150	100	100	200	200	50	50	400	400	400	400
150	400	150	150	-	-	-	-	600	600	600	600
50	50	50	50	-	-	-	-	500	500	500	500
75	75	150	125	-	-	-	-	300	350	350	350
50	50	50	50	100 K	100 K	100 K	100 K	350	300	300	300
50	50	50	50	100 K	100 K	100 K	100 K	300	200	200	200
300	300	100	100	-	-	-	-	400	400	400	400
100	100	75	75	-	-	-	-	600	600	600	600
25	100	50	25	-	-	-	-	-	-	-	-
310	300	200	150	-	-	-	-	-	-	-	-
350	400	320	200	-	-	-	-	-	-	-	-
400	400	400	400	-	-	-	-	-	-	-	-
				b. Side Lighting							
200	200	175	175	200	200	175	175	400	400	400	400
100	100	50	50	100	100	50	50	300	300	300	300
300	300	300	300	-	-	-	-	300	300	300	300
200	250	200	100	100 K	100 K	100 K	100 K	400	400	400	400
50	50	50	50	100 K	100 K	100 K	100 K	500	500	400	400

Table XXI (cont'd)

Load Carrying Equipment											
Model Erect				Model Prone				Rifle (Model Erect)			
Khaki	Tan	Green	OG	Khaki	Tan	Green	OG	Khaki	Tan	Green	OG
100	100	100	100	300 K	400 K	400 K	300 K	600	600	500	500
300	300	200	300	500	500	500	500	400	400	400	400
200	200	300	200	200	200	200	200	400	400	400	400
400	400	250	200	100	100	100	100	400	400	400	400
500	500	500	500	50	50	50	50	500	500	600	500
-	-	-	-	75	75	75	75	-	-	-	-
100	100	100	100	-	-	-	-	500	400	400	500
500	500	500	500	-	-	-	-	300	300	300	300
200	200	400	200	-	-	-	-	200	200	200	200
100	100	100	100	-	-	-	-	300	300	300	300
50	50	50	50	-	-	-	-	-	-	-	-
100	100	100	100	-	-	-	-	-	-	-	-
50	50	50	50	-	-	-	-	-	-	-	-
50	50	50	50	-	-	-	-	-	-	-	-
200	200	200	200	-	-	-	-	-	-	-	-
				c. Rear Lighting							
50	50	50	50	200 K	200 K	200 K	200 K	400	400	400	400
150	150	300	300	150 K	150 K	300 K	300 K	300	300	300	200
50	50	50	50	50 K	50 K	50 K	50 K	300	300	300	300
200	200	200	200	200 K	200 K	200 K	200 K	400	400	400	400
100	100	50	50	-	-	-	-	400	400	400	400
50	50	50	50	-	-	-	-	400	400	400	400
25	25	25	25	-	-	-	-	500	500	500	500
50	50	50	50	-	-	-	-	250	400	250	250
-	-	-	-	-	-	-	-	200	200	400	200

KEY: K = Kneeling

NOTE: All values in yards.

Table XXII. Detection Thresholds of Load Carrying Equipment and Rifles; Desert Test Series No. 3

Models Erect		Model Prone		Rifle (Model Erect)	
Tan w/OD Armor	Tan w/Tan Armor	Tan w/OD Armor	Tan w/Tan Armor	Tan w/OD Armor	Tan w/Tan Armor
		a. Front Lighting			
200	300	400	300	400	400
500	300	400	300	400	400
500	500	400	200	400	400
400	200	400	300	400	400
700	100	300	50	100	100
300	100	500	50	400	400
500	50	500	50	600	600
700	300	300	800	600	600
500	50	200	-	500	600
700	50	600	-	-	-
500	40	800	-	-	-
150	50	800	-	-	-
500	-	-	-	-	-
600	-	-	-	-	-
500	-	-	-	-	-
		b. Side Lighting			
500	500	200	50	600	600
500	500	200	50	600	600
200	50	500	500	600	600
200	50	400	50	500	500
200	50	400 K	400 K	500	500
200	200	500 K	500 K	500	500
200	125	-	-	500	500
100	50	-	-	200	200
[illegible]0	100	-	-	200	200
-	-	-	-	400	400
		c. Rear Lighting			
300	300	100 K	100 K	300	300
300	300	100	100	300	300
100	200	300	200	200	200
100	200	300	200	200	200
300	200	200	100	300	300
300	200	200	100	300	300
200	100			300	300
200	100			300	300

KEY: K = Kneeling. NOTE: All values in yards.

APPENDIX D

SPECTROPHOTOMETRIC REFLECTANCE DATA

AND CHROMATICITY DIAGRAM

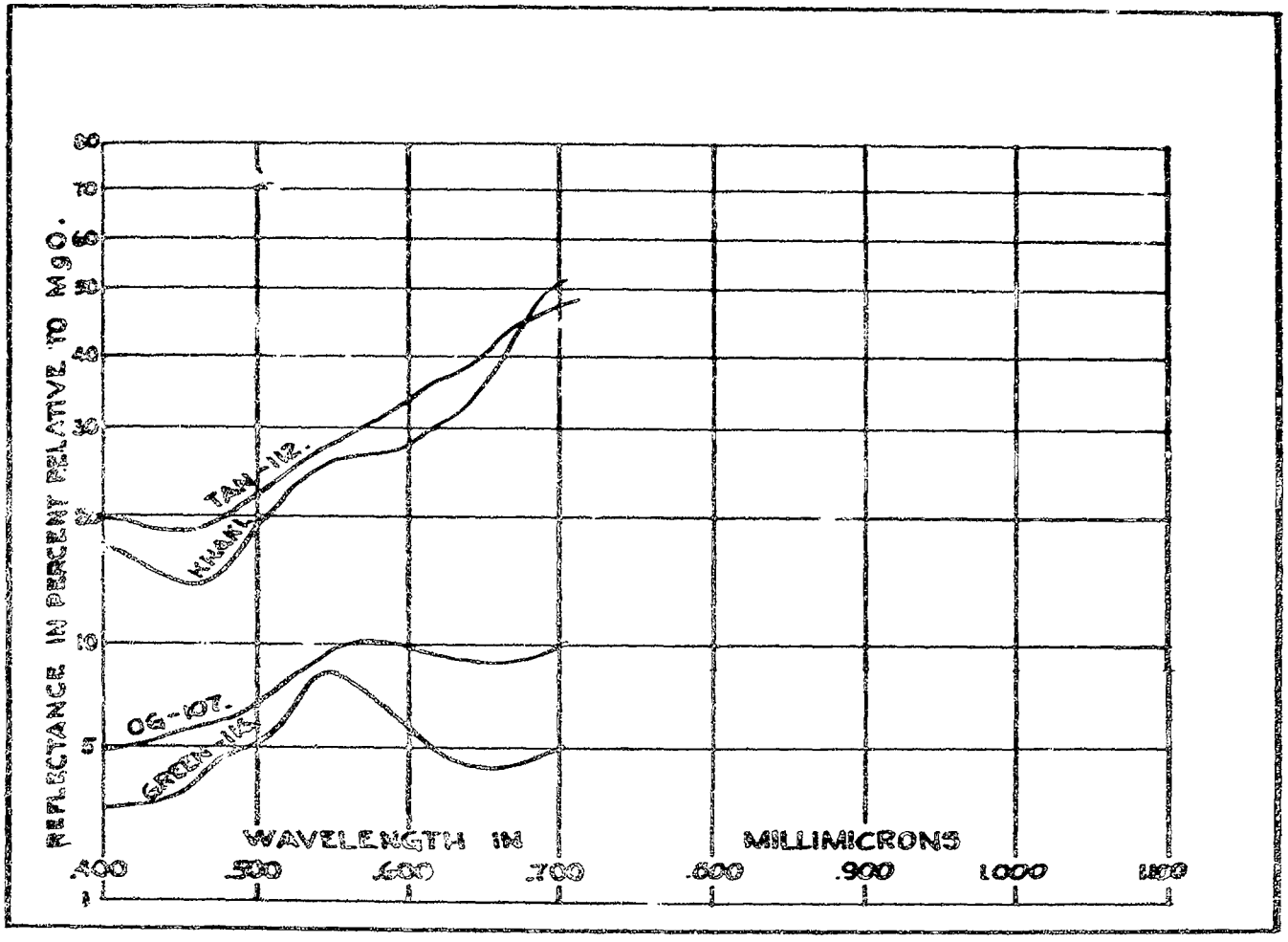


Fig. 60. Spectrophotometric reflectance of uniforms tested in desert. GE recording spectrophotometer, EEDL instrument No. II. Vertical scale adjusted to equalized munsell value steps.

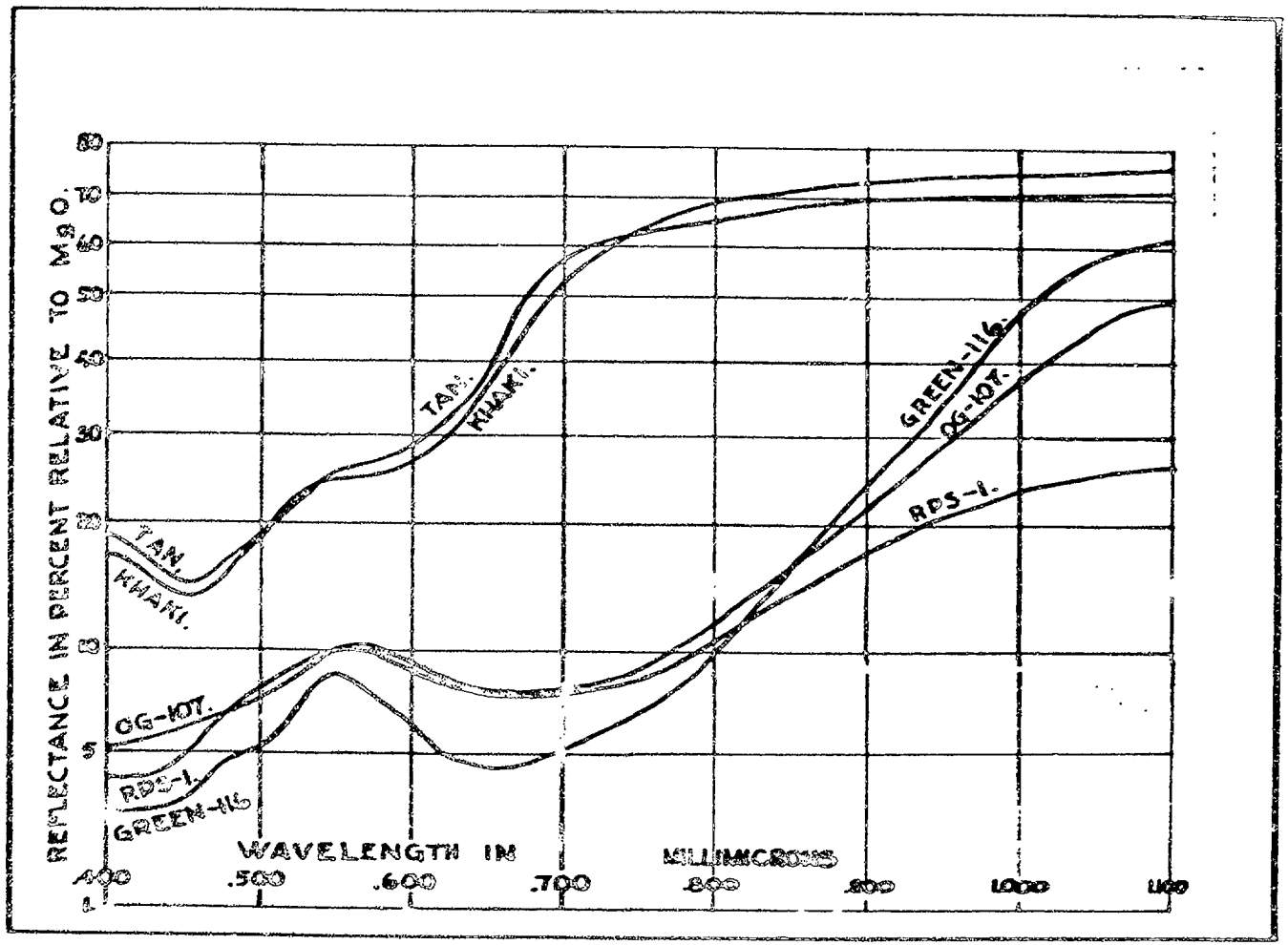


Fig. 61. Spectrophotometric reflectance of uniforms tested in Panama. GE recording spectrophotometer, EHOL instrument No. II. Vertical scale adjusted to equalized Munsell value steps.

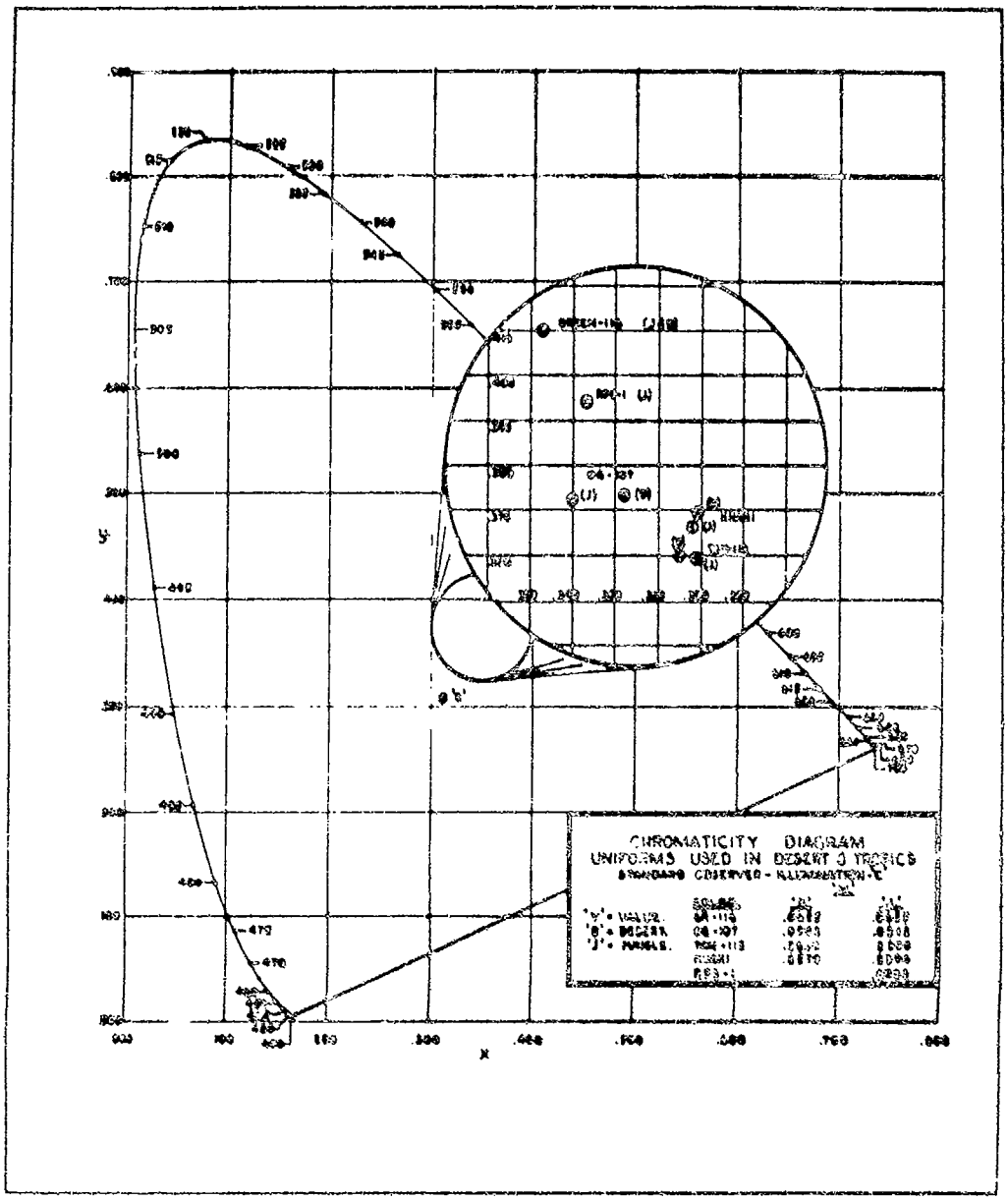


Fig. 62. Chromaticity diagram of uniforms used in desert and tropics.

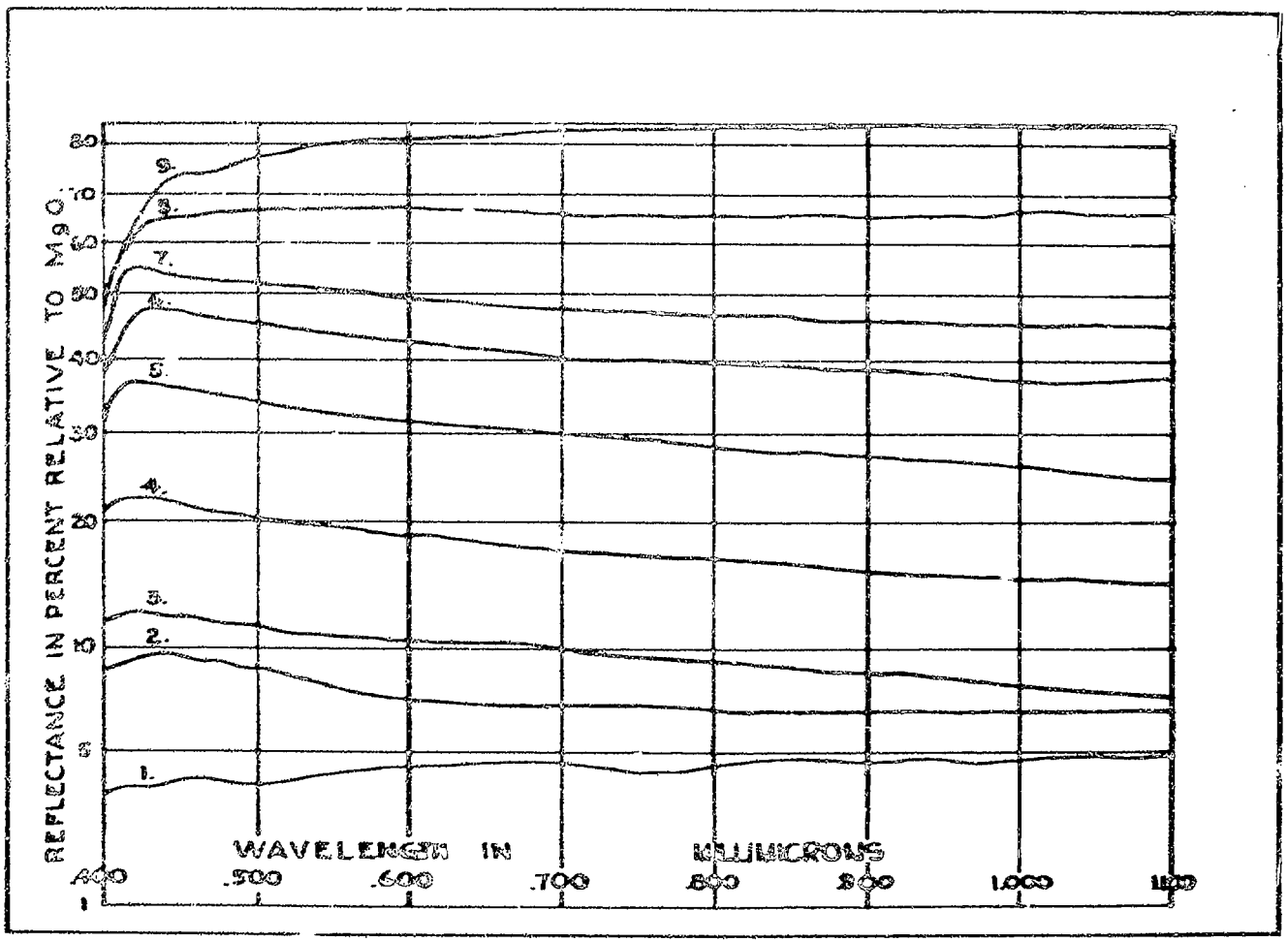


Fig. 63. Spectrophotometric reflectance of grey scale appearing in photographs.

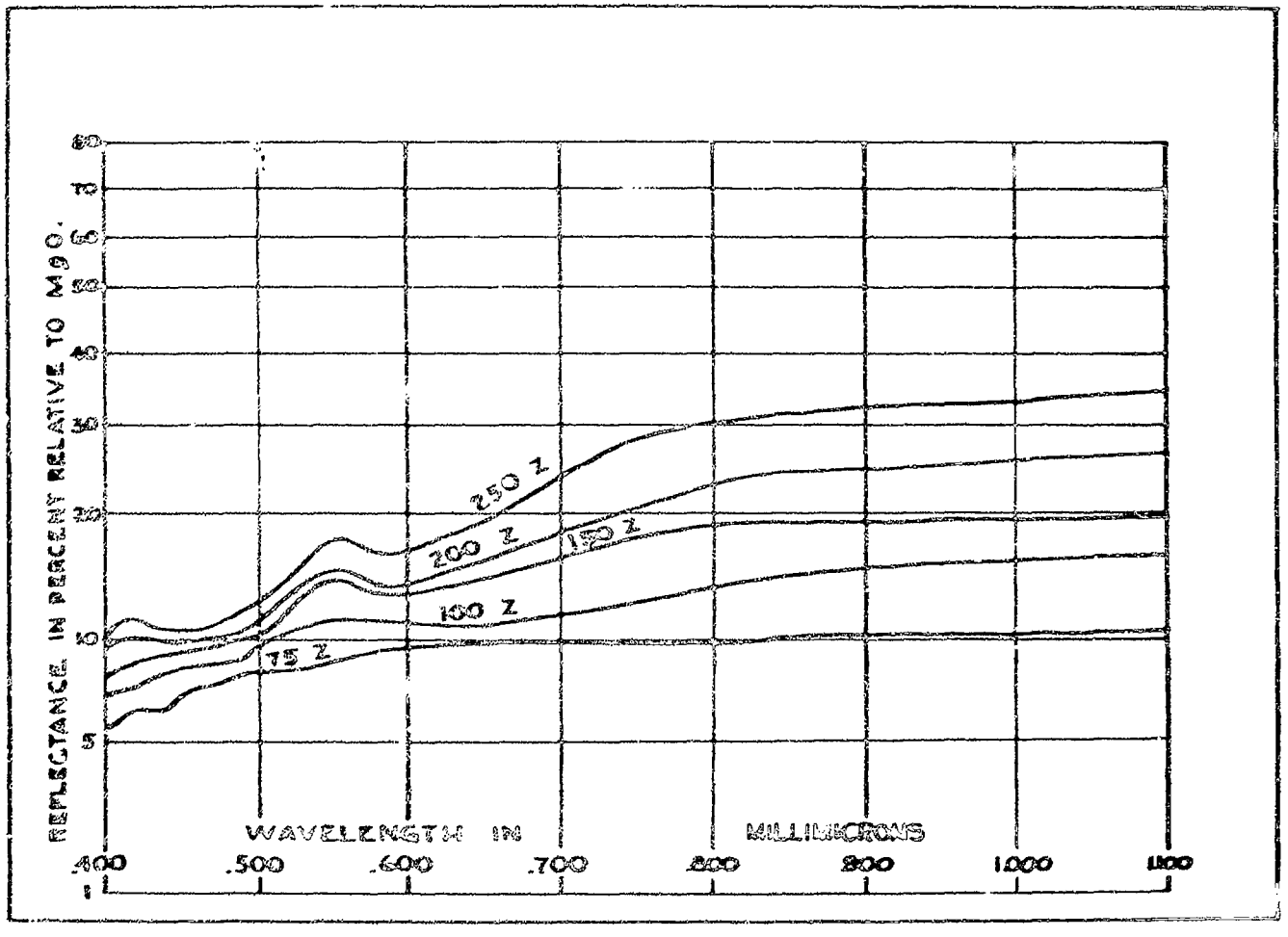


Fig. 6. Spectrophotometric reflectance of infrared test uniforms.

APPENDIX E

CLOTH SAMPLES

KHAKI NO. 1

TAN 112

OLIVE GREEN

RPS-2

GREEN 116

Category 2 - Cover and Concealment

DISTRIBUTION FOR USAERDL REPORT 1700-TR

TITLE Tan Versus Green Coloration for Combat Uniforms in Hot-Dry and Hot-Wet Terrains

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Report 1700-TR, 15 Nov 61, 167 pp, 64 illus, 22 tables
DA Project 8-31-02-004 Unclassified Report

Report covers a series of observations of live models conducted in sites located in the Southwestern United States and in the Panama Canal Zone. These observations compared the thresholds of detection and the relative conspicuousness of the whole and various individual portions of combat uniform ensembles in four primary colors--Khaki No. 1, Tan 112, Green 116, Olive Green 107. An additional series of experimental patterned and colored uniforms were observed in Panama. The report concludes in part that: (a) There is a significant military advantage gained from the use of tan coloration in hot-dry terrains (deserts) and from the use of green coloration in hot-wet (tropical) areas; (b) light tan coloration (as exemplified by the Khaki No. 1 and Tan 112 colors used in these tests) provides significantly superior camouflage over green and olive-drab colors for combat uniforms to be used in desert (hot-dry) and semidesert terrains; and (c) medium dark yellow-green coloration (as exemplified by the experimental summer temperate color QM Code EPS-1, Olive Green 107, and Green 116) provides significantly superior camouflage over the tan and khaki colors for combat uniforms to be used in tropical (hot-wet) terrains.

UNCLASSIFIED
1. Counterintelligence - Camouflage
2. Contracts - None

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2. Contracts - None

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